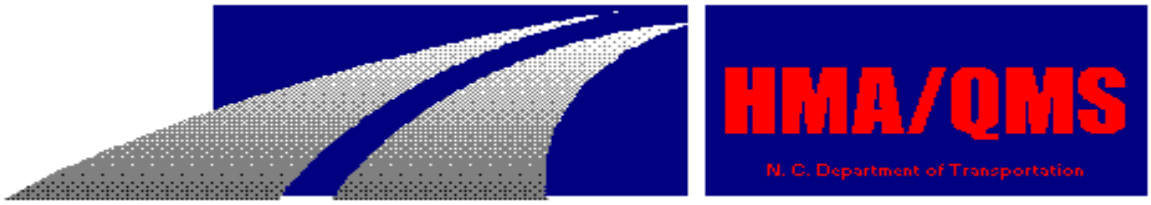
North Carolina
Department of Transportation



Density Gauge Operator's Manual

North Carolina Department of Transportation
Division of Highways
Materials and Test Unit – Soils Laboratory

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HMA/QMS ADDENDUM

ABSTRACT

Nuclear and non-nuclear testing is easy and very fast. This enables the Density Technician to take a greater number of tests in a given area. The greater the number of tests, the more reliable the tests' results will be. With nuclear or non-nuclear testing, the tester uses a table of random numbers (which will be explained later) to choose his/her test spots. This way, he not only finds out if the road has the required density, but also if the road has a uniform density. This is essentially a statistical approach to highway quality control, which is assuming a more important role in highway construction.

The use of nuclear techniques for measuring highway compaction dates back to the early fifties. Since that time the equipment has progressed from large homemade laboratory devices to commercially available, self-contained, portable devices designed specifically for compaction control work.

The strength of the radioactive sources used in the newer gauges is much less than that used in the early gauges. In fact, in some cases, the radioactive source strength has been reduced by a factor of 100. This, of course, reduces the health hazard and degree of training necessary. The gauges have become simpler to operate and are constructed to be more rugged and reliable.

Nuclear gauges are used to determine the compaction of ABC and Asphalt pavements; and recent studies have indicated a unique application to concrete consolidation control.

Non-nuclear gauges are a new technology to become available. The techniques for measuring compaction of asphalt with these devices were derived from experience gained with nuclear gauges. Non-nuclear gauges offer numerous advantages in that the devices provide test results within seconds, weigh less than a typical nuclear gauge, do not emit radiation, do not require special licensing, do not require radiation safety training and do not require gauge operators to wear a dosimeter.

It is essential that the operator become familiar with this manual along with the manufacturer’s operator manual for the particular device being used. Since the nuclear and non-nuclear testing programs are still evolving, this manual will be changed periodically to reflect new procedures.

INTRODUCTION

This manual is to serve as a ready reference to the QMS Density Technician. The HMA/QMS Specification contains several significant changes in the methods and techniques of nuclear or non-nuclear density control. The instructions, information, guidelines, forms, etc. contained in this manual are based on the HMA/QMS Specification. This text not only presents the concepts associated with nuclear or non-nuclear density testing of asphalt pavements but also some of the general concepts of the HMA/QMS Specification.

FIELD OPERATION PROCEDURES FOR TROXLER 4640B

When a new device is puchased the operator should read and become familiar with the manufacturer's operation manual. Knowledge gained from the operator's manual will help to ensure the gauge is operated safely and efficiently.

Turning the Gauge "ON"

The gauge uses rechargeable Ni-cad batteries *(included)* as a power source. When first turned on, the control panel display screen will fill with test characters before proceeding to the self-test.

To turn the gauge on, press ON.

After the "LCD" test, the display will be:

TROXLER 4640B
V: xxx SN xxxxx
Customer name
(TEST: xx sec.)

After the 300 second self-test the gauge will enter the "Ready" mode. In this state any of the gauge functions may be accessed.

The <READY> display is:

<READY>
mm/dd/yy
Avg.: xx
Time: xx mins.
BATT VOLTS xxx V

The first line of the display alternates between the current time and date. The second line of the display indicates any gauge options that are enabled such as "Average Mode". The third line indicates which count time is enabled. The last line indicates the current battery voltage.

GAUGE PARAMETER SET-UP - 4640-B

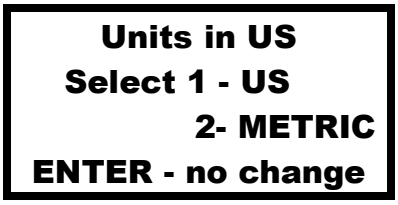
After unpacking your gauge and turning it "ON" there will usually be several parameters that you can initialize. These parameters do not usually require changing and may include the time/date, company name, count time, etc.

Units Selection

The 4640-B allows measurement results to be displayed in either metric or English units. Decide which selection you will be using and press SHIFT and SPECIAL.

The display will be:

Press YES two times and/or press 7 for the display:

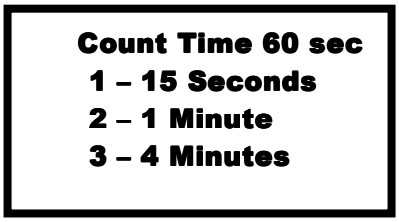


Press either 1 or 2 to select the required units.

Count Time Selection

The gauge provides three different count times for taking density readings. CURRENTLY, THE NCDOT REQUIRES THAT ALL NUCLEAR GAUGE DENSITY MEASUREMENTS BE TAKEN WITH A ONE-MINUTE COUNT TIME.

To set count time press TIME for the display:



Source Rod Positions

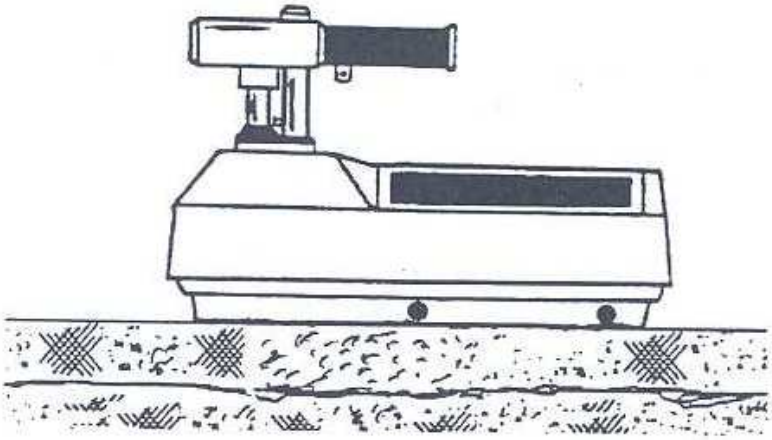


Figure 1

Safe Position

The source rod handle must be in the upper position. The plunger must engage in the notch located on the index rod.

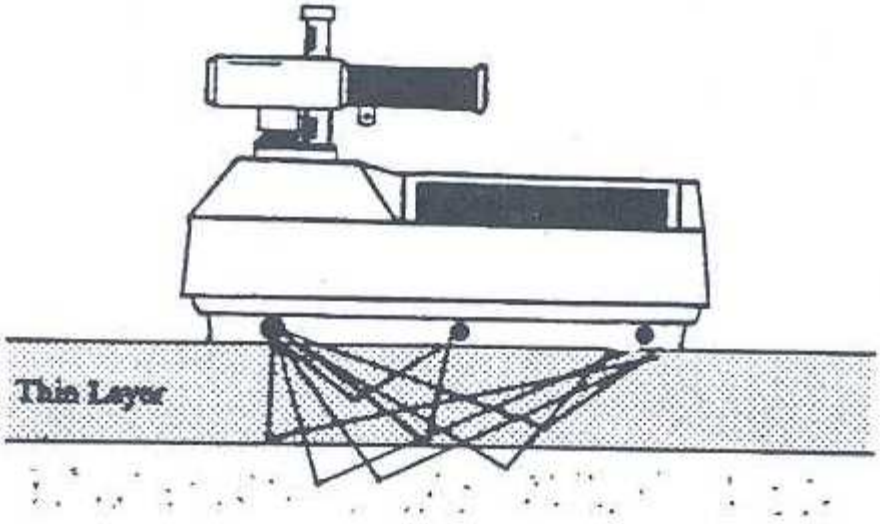


Figure 2

Measure Position

The source rod handle must be all the way down! The handle must be resting on top of the stop pin.

Taking the Standard Count

The 4640-B uses a Cesium-137 gamma source for taking density measurements. This low-level radioactive source undergoes a natural decay process, which results in a gradual loss of strength. The time required for the source strength to diminish by 50% is referred to as the *half-life*. The half-life of Cesium-137 is approximately 30 years.

To compensate for the source decay and to check if a gauge is malfunctioning, a daily reference *Standard Count* is performed. It is very important to take a Standard Count on a daily basis to ensure the highest accuracy/precision possible with the gauge.

On days when a control strip is being placed, the Department's QA technician should witness the QC technician's standard count procedure. Likewise, the Contractor's QC technician should witness the QA gauge operator's standard count procedure.
The gauge is equipped with a reference block and an air gap spacer for taking the Standard Count. Place the reference block on a dry, flat surface at least 10 feet (3 meters) from any large vertical surface (i.e. concrete block wall) and at least 33 feet (10 meters) from any other radioactive source. The Standard Count MUST be taken at the project site on the material being tested.

Place the spacer on the reference block and then place the gauge on top of the spacer. The gauge must be in the "SAFE" position. The handle end of the gauge should rest over the two posts on the spacer.

The QC and QA Nuclear Gauge technicians should also calculate the maximum and minimum standard count range that would be allowed on the project for that material for progressive days until a new control strip is placed. These numbers should also be recorded on the correct forms.

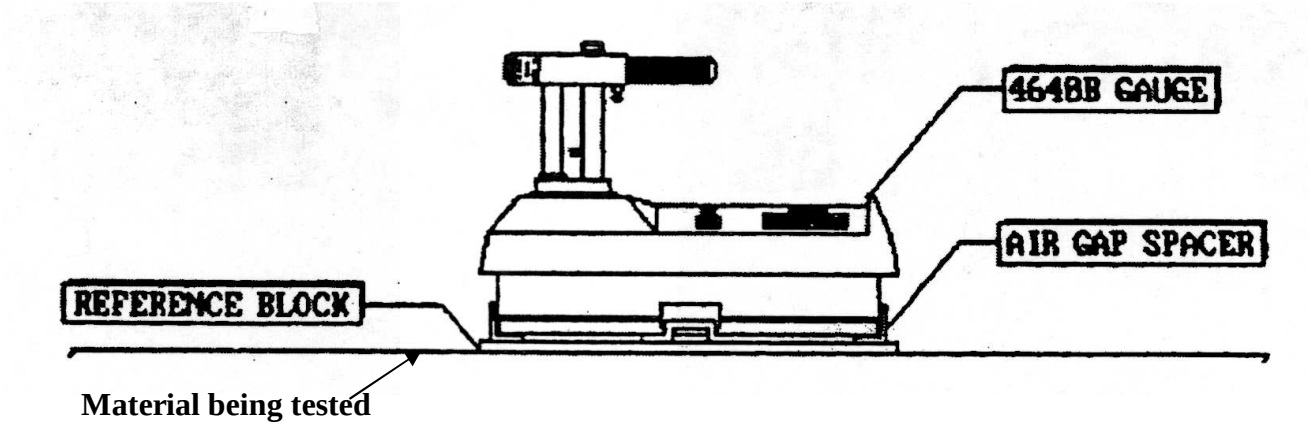


Figure 3

Standard Count

Press STD for the display:

Press YES.

Check the gauge position. Press ENTER to start the count.

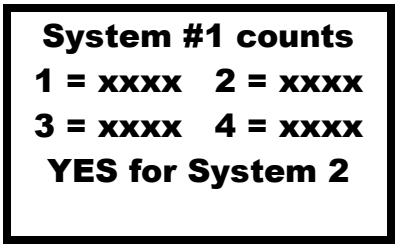
After the count is completed press YES to accept the new count.

NOTE: The 4640-B is equipped with two methods of testing the reference Standard Count. The first method compares the new Standard Count with the average of the last four (4) Standard Counts. This method is the *Multi-Standard Mode*. The second method compares the new Standard Count to the decay corrected factory calibration reference Standard Count. This factory Standard Count is theoretically decay corrected for the time elapsed between the new references Standard Count and the factory reference Standard Count. The new count is compared to the corrected calibration count and is referred to as the *Single-Standard Mode*. Refer to information on selection Single-Standard mode or Multi-Standard Mode.

The Pass/Fail tolerance is based on a +/-1% variation for System 1 reference Standard Counts and a +/-1.2% variation for System 2 Standard Counts (multi-standard and single standard mode).

The last four (4) "Standard Counts" stored in gauge memory may be viewed.

Press SHIFT and SPECIAL. Press YES four (4) times and/or press 12 for the display:



Press YES to view the counts for System #2.

System #2
1 = xxxx 2 - xxxx
3 = xxxx 4 = xxxx
YES to Exit

Site Preparation/Gauge Positioning

The 4640-B Thin Layer Density Gauge is designed for use on asphalt surfaces and consequently will not require a great deal of site preparation.

IMPORTANT: Keep the gauge turned parallel to the direction of the paver and rollers.

- Remove any loose material (sand, aggregate, etc.) from the test site.
- Ensure that the gauge does not "rock." It must remain level and steady. If rocking occurs, find a more suitable test site within a 3 foot radius. If you are taking a measurement at a core site in a Control Strip you may move the gauge up to 12 inches away from the site to level the gauge. Cut the core from within the gauge foot print.

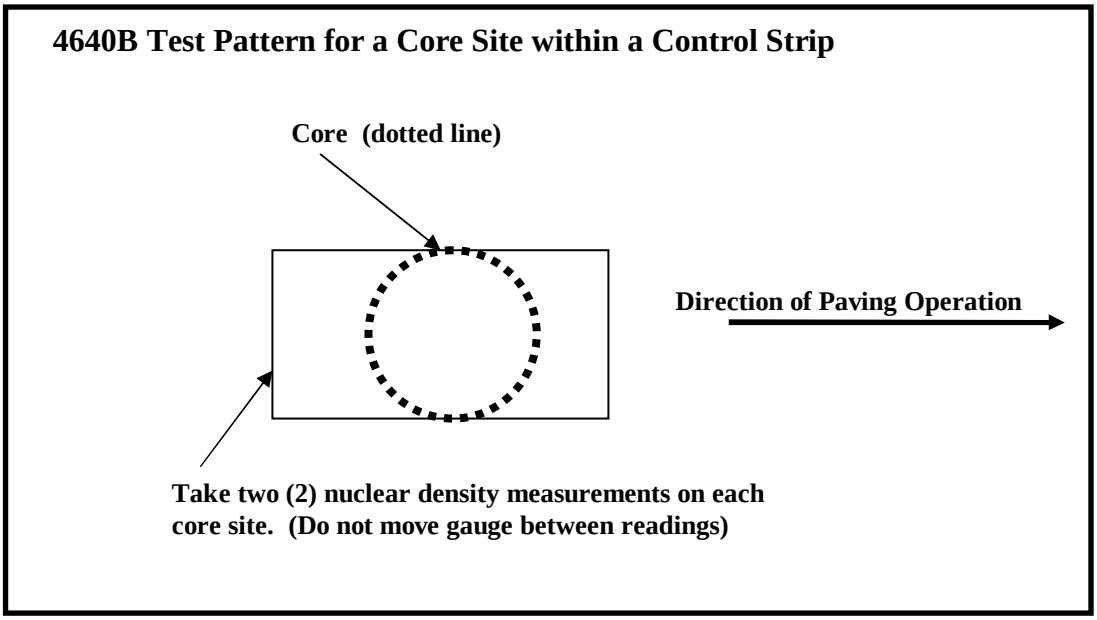


Figure 4

TAKING A MEASUREMENT

Overlay Thickness Selection

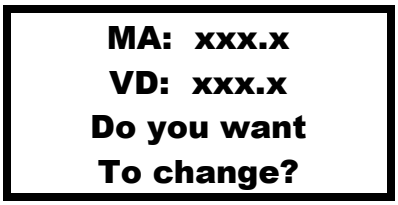
Input the overlay thickness prior to taking a measurement with the 4640-B. This will ensure the underlying material does not influence the readings.

Press THICK for the display:

Input the thickness of the overlay and press ENTER.

Marshall/Voidless Density Parameters

Input the target density prior to taking a measurement. Press MA/VOIDLESS for the display:



Press YES and input any target Marshall and Voidless Density values.

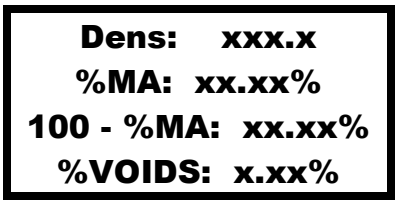
NOTE: The "Voidless" density is the maximum density obtained in laboratory tests.

Taking a Reading

Ensure the gauge has passed the standard count procedures.
Place the gauge over the test site. Release the gauge handle and push it down until the handle is resting on top of the stop pin.

Press START:

After the count time has elapsed, the display will be:



NOTE: If *Surface Voids* Mode has been enabled, the surface voids value will be displayed in place of the density value.

Viewing the Counts

Press SHIFT and RECALL to view the actual counts for detector systems 1 and 2.

Creating a Project

Data is stored in the 4640-B under a *project number*. When a project is *active*, all readings will be stored in memory under this project number. This function allows data to be retrieved and printed (or downloaded to a computer) for later use.

The *Project Function* allows projects to be created, retrieved, viewed and/or erased.

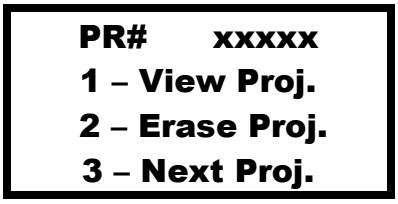
Press SHIFT and PROJECT for the display:

Create a New Project

Press YES and input the number of a new project. The project will be active until a new project number is entered. All gauge readings that are stored will be stored under the new project.

View/Erase Project

Press NO.

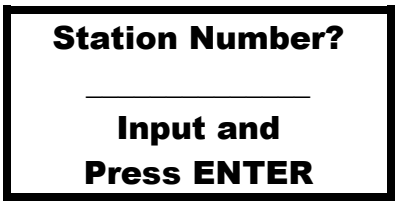


Select the project number required and follow all instructions on the gauge display.

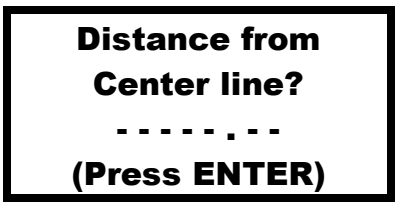
Storing a Measurement

After reviewing the data the reading may be stored under a *Project Number*. This function allows the data to be recalled and printed at a later time.

When the measurement has been completed press STORE. The display will request a station number.



Input a numeric station or reading number (up to 6 characters) and press ENTER. The display will request the distance from the centerline.



Input the distance (if applicable) and press ENTER. The display will request if the measurement was to the *Left or Right* of the centerline. Press 1 or 2.

Additional information may be stored. This information may be grid coordinates, mix type, or any other numeric information (up to 12 characters per line). Press YES to continue storing information. Press NO to exit.

Printing Measurement Data

Project data may be printed at any time after the readings have been taken and stored into the project.

Press SHIFT and PRINT. The display will be:

Connect the printer to the serial port located on the front of the gauge (refer to information on setting the serial port parameters).

Press 1 to select (1) project. Press 2 to print <u>all</u> projects.

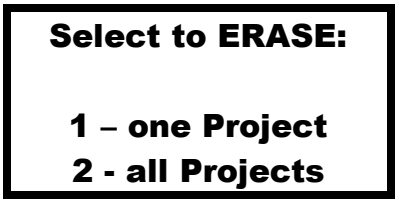
If 1 is selected, the gauge will display the first project in memory.

Press 1 to print the project. Press 2 to scan for another project.

Erasing a Project

The *Erase Function* allows project data to be erased or removed from gauge memory.

Press SHIFT and ERASE. The display will be:



Press 1 to select one (1) project only.

Press 2 to erase all projects stored in the gauge.

Accidental Erasure

If data is accidentally erased press SHIFT and SPECIAL.

Press 2 to select the *Recover Erase* function.

When a new device is puchased the operator should read and become familiar with the manufacturer's operation manual. Knowledge gained from the operator's manual will help to ensure the gauge is operated safely and efficiently.

Turning the Gauge "ON"

The gauge primarily uses Ni-cad batteries as a power source; however, the gauge also contains six AA alkaline batteries for a backup power source. When the gauge is first turned on, the software tests the display, performs a short self-test, and displays the battery status. NOTE: The gauge should be turned on at the office prior to leaving for the project to allow the gauge to warm-up.

To turn the gauge on, press ON.

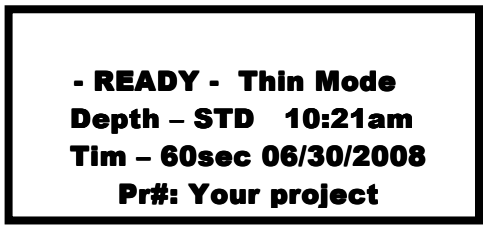
After the self-test the display will be:

The first line indicates if the charger is connected and the next two lines display the status of the Ni-cad and alkaline batteries. To view the battery voltage, press the "down" arrow key.

Press, ENTER and the gauge will go into a warm-up mode to allow the electronics to warm-up (approximately 10 minutes).

After the warm-up, the gauge will go into the ready screen.

The display will be:



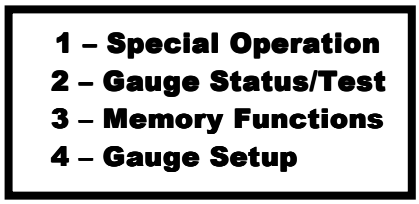
From the ready screen any gauge function can be accessed.
To conserve power the gauge will go into a sleep mode after thirty seconds of no use. All data and settings are protected. To exit sleep mode, press any key OTHER THAN ON OR OFF.

BASIC PARAMETER SET-UP: 3450 GAUGE

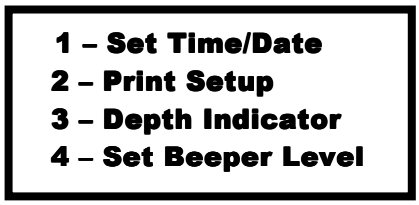
Setting Measurement Units

Prior to taking measurements, the operator should determine if the project is metric or English and set the gauge accordingly.

To execute the set units function, press SPECIAL for the display:

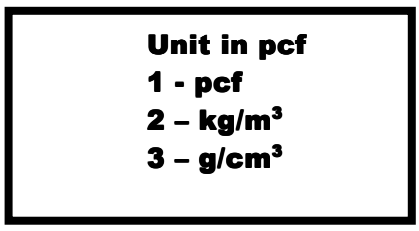


Press 4 to enter gauge setup menu.
The display will be:



Use the "down" arrow key to scroll through the menu. Press 8 for set unit function.

The display will be:

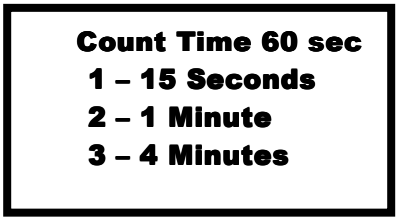


Enter the number of the desired unit for testing.

Count Time Selection

The gauge provides three different count times for taking density readings. CURRENTLY, THE NCDOT REQUIRES THAT ALL NUCLEAR GAUGE DENSITY MEASUREMENTS BE TAKEN WITH A ONE-MINUTE COUNT TIME.

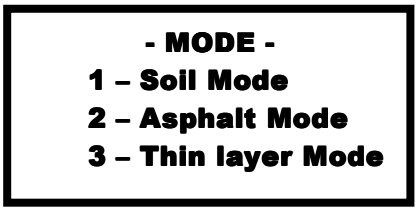
To set count time press TIME for the display:



Measurement Mode Selection

The gauge may be utilized on asphalt, base course, or soil, and it provides three different testing modes: Soil mode, asphalt mode, and thin-layer mode. The gauge must be set in soil mode for testing base course or soil. For testing asphalt on QMS projects, the gauge must be set in thin-layer mode.

To select mode press MODE for the display and select 3 for the thin-layer mode:



Once the thin-layer mode is selected, the gauge prompts for the overlay thickness. Use the number keys to enter the overlay thickness and press the ENTER key.

Taking the Standard Count

NOTE: The front of the gauge is closest to you when the 3450 is placed with the source rod to the left and the control panel to the right. The handle contains the trigger mechanism, which is used to position the source rod on the notched index rod. The source rod should always be in the SAFE position when the gauge is not in use.

All Troxler nuclear gauges utilize low level radioactive sources for taking measurements. The sources in the 3450 gauge have a half-life of 30 years for Cesium 137 and 433 years for Americium 241: Beryllium. For example, if a nuclear gauge is manufactured with 8 mci of Cesium 137, then in 30 years only 4 mci of Cesium 137 will be present. To ensure accurate testing a STANDARD COUNT must be taken to compensate for the continuous radioactive decay. The radioactive decay is a known occurrence and will not compromise the accuracy of the gauge provided the standard counts are taken. It is important to take the standard count when a gauge is initially received from the factory and prior to taking measurements at the job site.

The gauge should be turned on before leaving for the work site. This allows the gauge to go through the self-test/warm-up routine and the standard count can then be taken upon arrival at the work site without delays.

On days when a control strip is being placed, the Department's QA technician should witness the QC technician's standard count procedure. Likewise, the Contractor's QC technician should witness the QA gauge operator's standard count procedure.
The gauge automatically compares the new standard count to the average of the last four standard counts. The new standard count will "pass" if it is within +/- 1% for each density system average (DS 1 and DS 2) and +/- 2% of the moisture average. Record the standard count on the correct forms. The QC and QA Nuclear Gauge technicians should also calculate the maximum and minium standard count figures that would be allowed on the project for that material for progressive days until a new control strip is placed. These numbers should also be recorded on the correct forms.
Place the REFERENCE BLOCK on a flat surface at least three meters (10 feet) from any building or structure and a minimum of ten meters (33 feet) from any other radioactive source. Do not use truck beds, tailgates, tabletops, etc. To ensure the highest degree of accuracy, the Standard Count MUST be taken at the project site on the material to be tested.

Place the gauge on the reference block as shown in the figure below, making sure the block top and gauge base are clean and smooth. The gauge must be positioned between the raised edges of the block with the right side of the gauge firmly seated against the metal butt plate on the block.

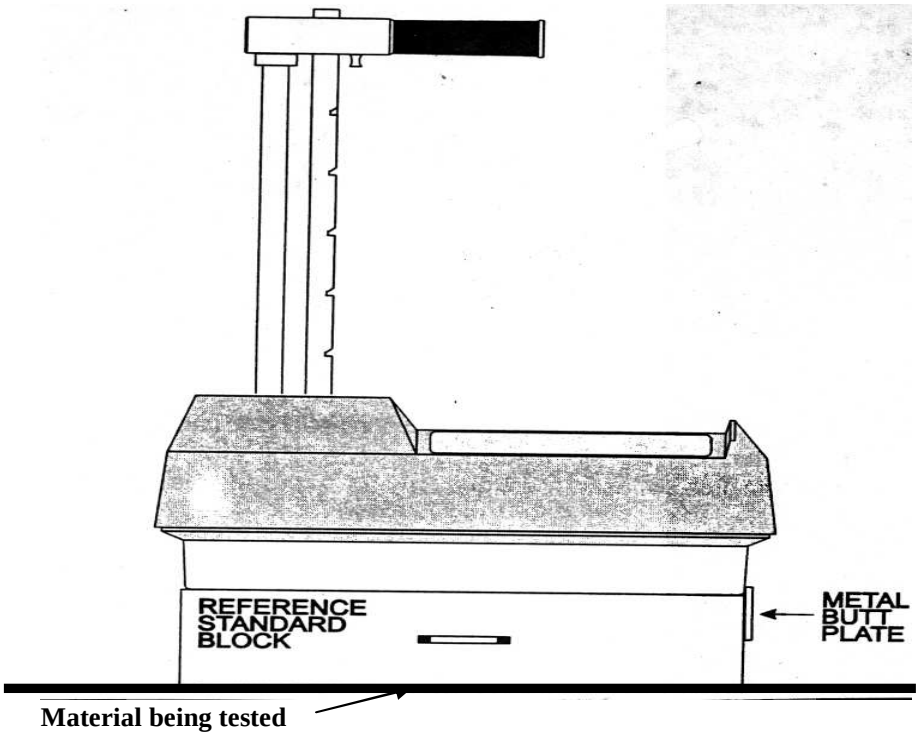
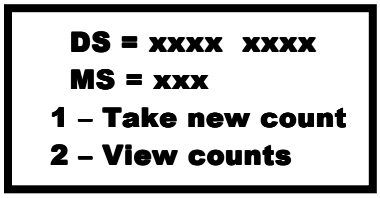


Figure 5

Standard Count

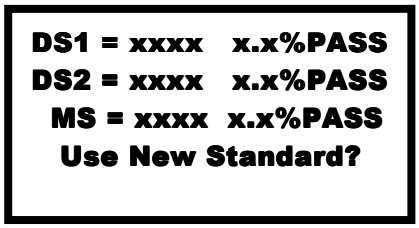
To begin taking a standard count, press STANDARD for the display:



To take a new standard count, press 1. To view the last four standard counts, press 2 and scroll through the counts by pressing the ENTER key.

Press 1 for the following display:

Press, ENTER to start the standard count. After the standard count, the gauge displays the results:



If a "PASS" is displayed by all three standards then the Standard Count is acceptable and can be used for the rest of the day. If "FAIL" is displayed for any of the standards, determine if anything in the surrounding area may have influenced the Standard Count. Check for structures or vehicles that may have been too close or possibly another nuclear device nearby. Also inspect the gauge and reference block to verify they are set up properly for a standard count. If all conditions are normal, do not accept the standard count just taken: Press NO and take another Standard Count.

NOTE: If the second Standard Count fails and any one standard did not fail by a large percentage (4% or greater), take four new standard counts to replace the four Standard Counts stored in memory. The fifth Standard Count should pass. Do not erase other standards stored in the gauge. If it does not pass, or if a Standard Count fails by 4% or greater call the soils lab (919) 329-4150.

If the Standard Count passes, record the results and press YES.

Calibrate Depth Strip

Once the Standard Count is complete, the depth strip will require calibrating. The gauge will display:

Depth Calibration
Set Rod To BS

And Press ENTER

To calibrate the depth strip, place source rod in the BS (backscatter) position and press ENTER. NOTE: If the source rod is not placed in the BS position during calibration, all density readings will be effected.

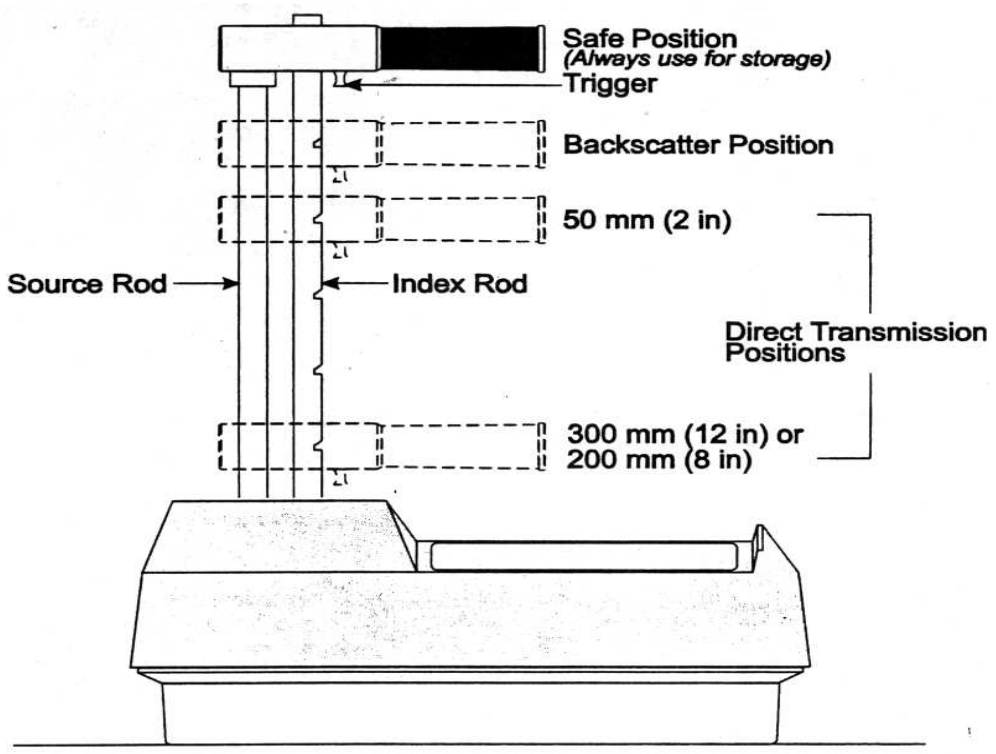


Figure 6

Source Rod Positions

Site Preparation/Gauge Positioning

The 3450 Density Gauge is designed for use on asphalt surfaces and consequently will not require a great deal of site preparation.

IMPORTANT: Keep the gauge turned parallel to the direction of the paver and rollers (see diagram below).

- Remove any loose material (sand, aggregate, etc.) from the test site.
- Ensure that the gauge does not "rock." It must remain level and steady. If rocking occurs, find a more suitable test site within a 3 foot radius. If you are taking a measurement at a core site you may move the gauge up to 12 inches away from the site to level the gauge. Cut the core from within the gauge footprint.

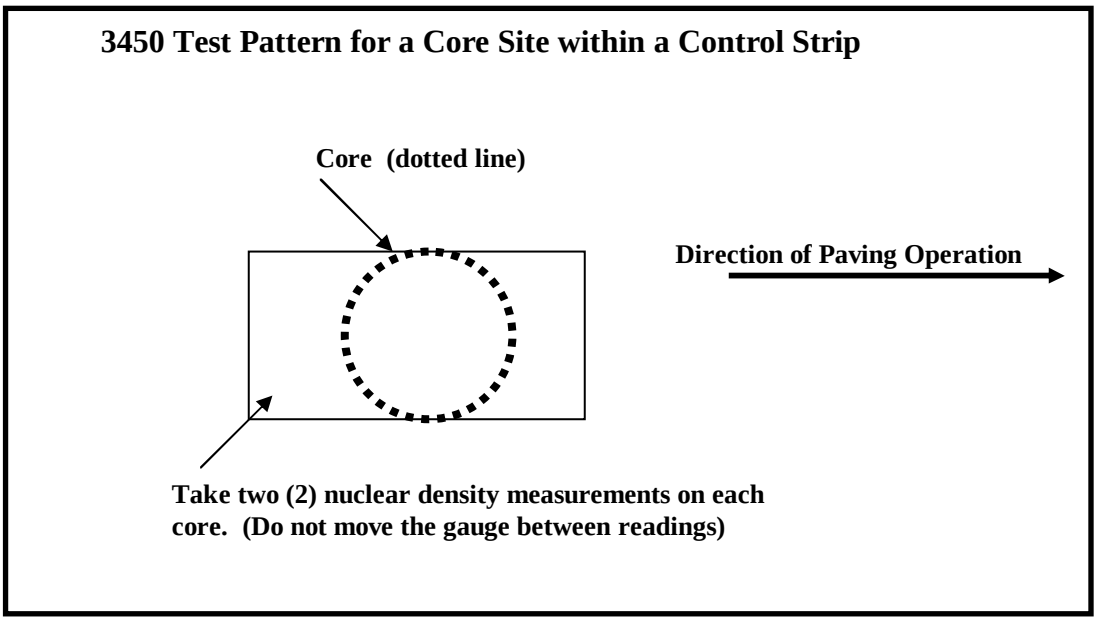


Figure 7

Entering a Target Density

Prior to testing asphalt for density acceptance, a target density must be entered into the gauge. Once the target density is determined, press TARGET for the display:

```
1 – PR = xxx.x
2 – MA = xxx.x
3 – Voidless = xxx.x
4 – Voidless/MA = pair
```

Press 2 to input target density for asphalt. The display will be:

```
Marshall Values:
1: xxx.x  2: xxx.x
3: xxx.x  4: xxx.x
5: New    6: Disable
```

Press 5 and input a new target value. After the value is entered press ENTER. The gauge will then ask if the operator wants to store the value in memory. To store the target value, press YES, and then choose one of the storage cells (1-4). Entering a new target value in a storage cell will erase an existing target value stored in the same cell. The stored target value will be saved and can be accessed for later testing. When prompted to store a target value, the operator may press NO and the value will not be entered into a memory cell, however; the value will remain the existing target value.

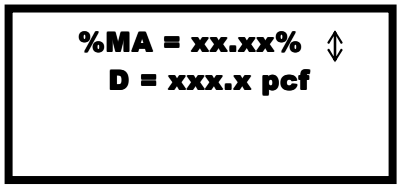
Taking a Reading

Place the gauge over the test site. Release the gauge handle and push it down until the handle is in the first notch below the safe position (BS position).

Press START and the gauge will display:

Press START again:

After the count time has elapsed, the display will be:



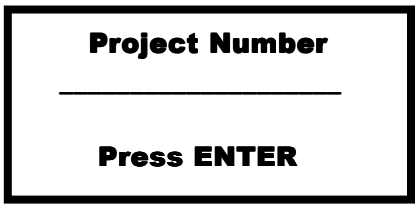
To view the actual counts for the detector systems 1 and 2 press the either arrow key.

Storing Project Data

The project function allows a unique project number (file) to be created. When the project number is active, density readings can be stored under that number and then either printed or downloaded to a computer.

To access the project function, press the PROJECT key. The display will be:

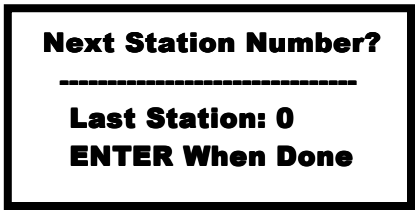
The first line displays the current project number. Use the arrow keys to scroll project numbers that are in gauge memory. When the desired project is displayed, press 1 to enable the project. To create a new project, press 2 at the project menu. The display will be:



The gauge then prompts for a project ID number. The project ID number is only an alternate project identification number; therefore, it is not necessary. Press ENTER to get to the display shown below.

Press YES and the gauge will enable the new project. The gauge will then return to the ready screen. Verify that the correct project number is displayed on the last line of the display screen.

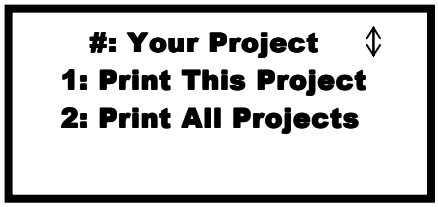
After taking a measurement, the operator can store the data in the selected project by pressing STORE. The display will be:



After entering the station number press ENTER. The gauge will then prompt the operator to enter additional information. The operator can enter the distance from centerline and any additional information.

Printing Data

To print the stored data press PROJECT to enter the project menu. Press 4 to enter the print function. The display will be:



Use a serial printer cable to connect the nuclear gauge to the printer (or computer). Refer to the Troxler manual for setting the correct baud rate in the gauge. To print a single project, use the arrow keys to scroll through the stored projects. When the gauge displays, the desired project, press 1. To print all projects press 2.

Erase Projects

To erase a project, press PROJECT. The press 5 and the gauge will display.

To erase a single project, use the arrow keys to scroll through stored projects. Once the gauge displays the desired project, press 1. The gauge will then display “Are You Sure”, press YES.

Recover Erase

If project data is erased accidentally, the recover erase function may be able to recover the lost information. For the recover erase function, press SPECIAL. Press 3 to access the memory function menu. To attempt data recovery, press 2.

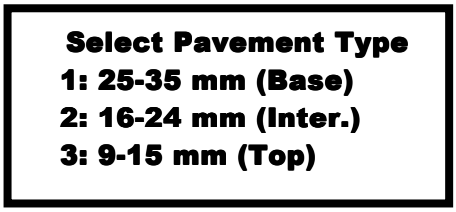
When a new device is puchased the operator should read and become familiar with the manufacturer's operation manual. Knowledge gained from the operator's manual will help to ensure the gauge is operated safely and efficiently.

Turning the gauge "ON"

The PQI gauge uses nickel metal hydride batteries as a power source and must be fully charged prior to using the gauge for the first time. These batteries with a full charge will provide approximately 13 hours of normal operation.

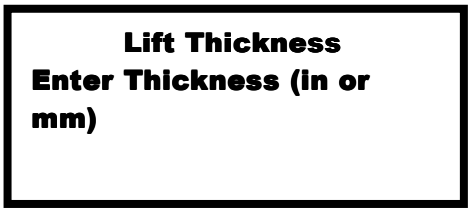
To turn the gauge on press ON.

After the self test the screen will prompt the operator to enter in the "Pavement Type"

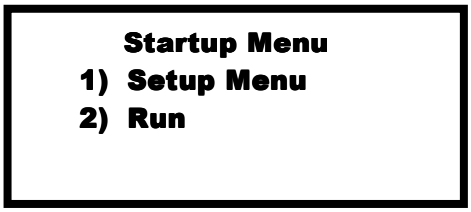


Enter "3" to select surface mix type. The gauge will prompt the operator to enter a Lift Thickness.

Select "1" for English units or "2" for metric. The gauge display will prompt for a lift thickness value.



Using the keypad enter the depth of HMA being placed and press "Enter". The gauge will then enter the "Startup Menu" screen as shown below.



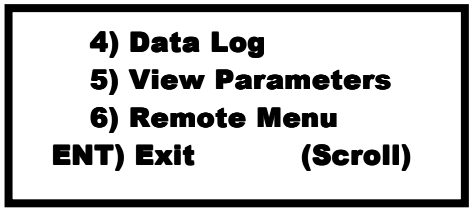
Test Block Procedure

To verify the PQI device is operating properly an initial PQI Test Block Procedure must be performed after purchasing a new gauge or following calibration/repair of an existing device. This initial Test Block Procedure will establish a baseline for future Test Block Procedures that are to be conducted on the material being tested at the beginning of each day's production. A representative of the Department should verify Test Block results are within tolerance of the initial Test Block Procedure. If the Test Block results do not fall within tolerance the device can not be used for acceptance testing and the manufacturer should be notifed for additional guidance regarding calibration/repair of the device itself. The PQI Test Block can be purchased at TransTech and a step-by-step procedure manual can be found at: http://www.transtechsys.com/products/pro_products_main.htm
Records of calibration and Test Block results must be maintained for verification by a Department representative.

Basic Parameter Set-up

If gauge testing parameters need to be entered or verified press "1" to enter the Setup Menu. The display will be as follows:

Since density readings will be stored in gauge memory, verify date and time and adjust if needed. Additional menu listings, as shown in the following diagram, can be viewed by pressing the "Down" arrow.



From this display the operator can press ENTER to exit, enter a desired menu function by pressing the corresponding number, or press the down arrow to return to the first setup menu display.

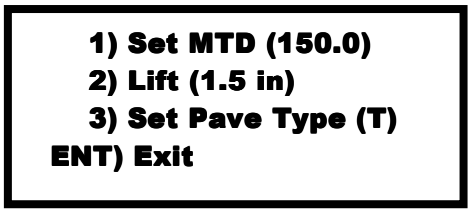
Setting Measurement Units

From the Setup Menu select the "Displayed Units" by pressing "3". The LCD will display the following:

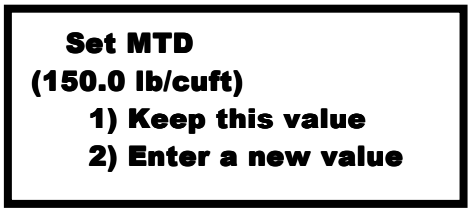
From this display the operator can press the appropriate number to change any of the units. Since the Department's specifications are based on percent compaction, "% Compaction" should be displayed when testing NCDOT projects. Press ENTER to return to the Setup Menu functions.

Entering a Target Density

Input the Target Density prior to taking a measurement. From the Setup Menu function press "2" for "Mix Information". The display will be as follows:



Select "1" and the display will be:

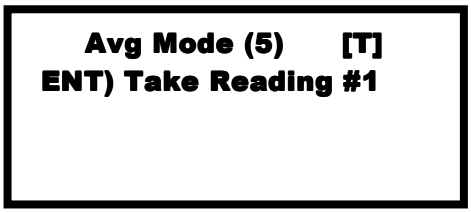


Press "1" to keep the current value and return to the Setup Menu. Press "2" to enter a new value. Use the keypad to enter a new target density.

Measurement Mode Selection

When testing with a PQI device at an individual test site within a Test Section or individual core site within a Control Strip, a total of five measurements will be required at each site. Taking more density measurements reduces variability providing a better representation of asphalt density. Increasing the number of density readings is possible due to the short count time required to take a density reading. The PQI device displays the results in approximately 3 seconds. The PQI also provides an "Average" mode function which averages 5 consecutive individual readings and displays the final result for recording. The stored density measurements are printed and submitted with the required QMS density forms to the appropriate QA representative.

To select the mode, press "Mode" until the screen displays the following:



Site Preparation/Gauge Positioning

- Remove any loose material (sand, aggregate, etc.) from the test site.

- If moisture is noticeable on the surface wait for the moisture to evaporate or remove the moisture with an absorbent cloth. Moisture will effect PQI measurement readings, monitor test results carefully. To ensure the highest degree of accuracy, moisture readings should remain relatively constant. Do not accept any density measurements when the "Relative Water Value" (H_2O) is above 5. If the relative water value is above 5 allow the test site to dry and take another measurement. Repeat this procedure until the value drops to 5 or below. Relative Water Values should remain relatively constant between measurements. If the value varies by more than 1 % do not accept the reading. Allow the test site to dry to a constant moisture value and retest.

- Ensure the bottom of the gauge is clean and the device does not "rock" when place on the mat. The device must remain level and steady. If rocking occurs, find a more suitable test site within a 3 foot radius. When taking measurments around a core the gauge operator may move the gauge a few inches away from the core location to level the gauge, but the core must be cut from the center of the 5 gauge readings. Refer to the following diagram for a typical PQI test pattern for a core site in a Control Strip and test site within a Test Section.

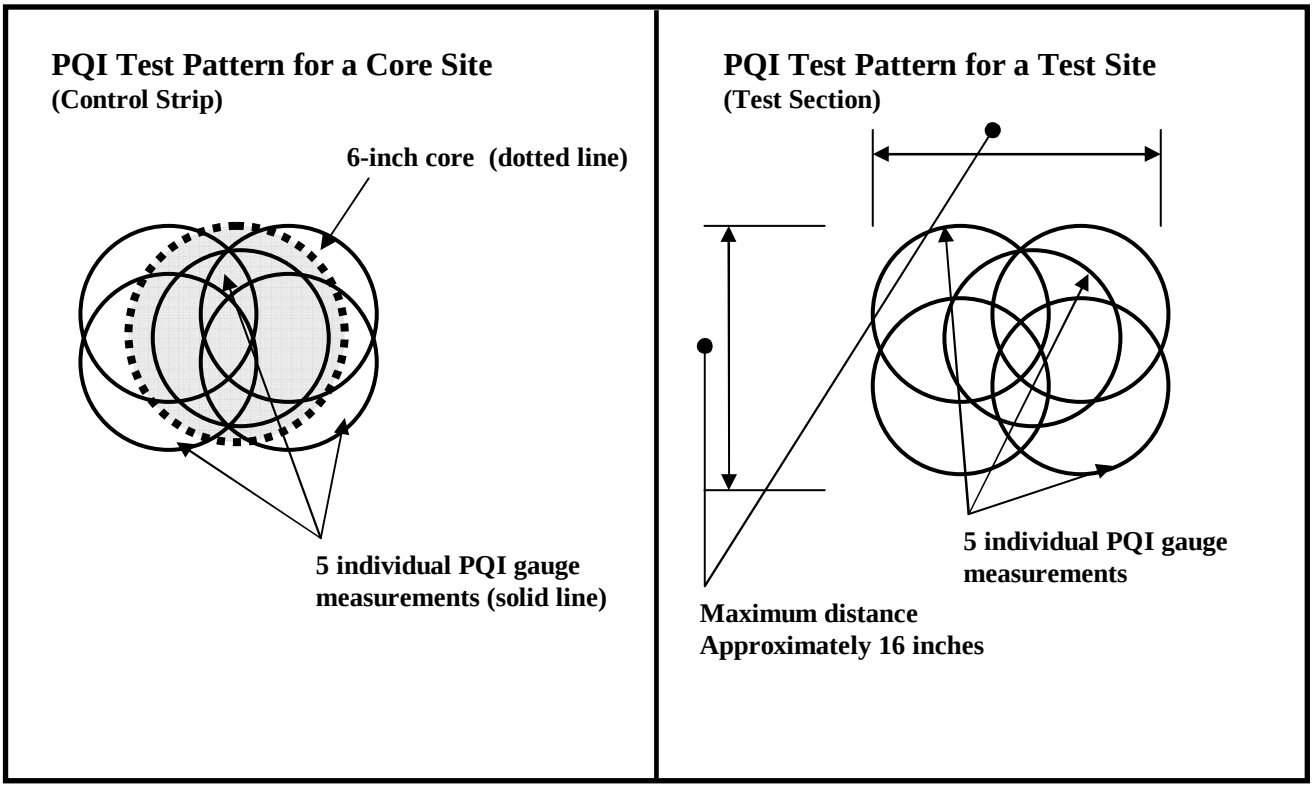
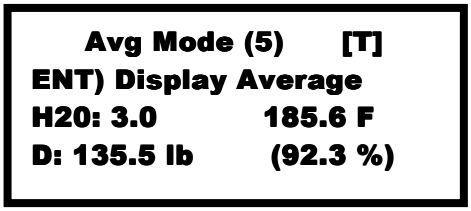
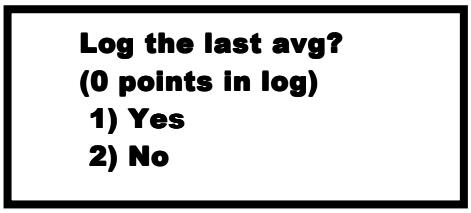


Figure 8

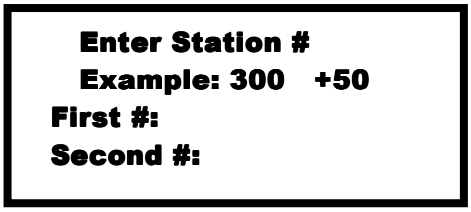
Press "Enter" to take the first reading. DO NOT TOUCH the gauge while it is taking a reading. Once the reading is complete move the gauge and take another reading. Repeat the same steps until all five readings are obtained. Press "Enter" to display the average of the five measurments (refer to diagram below).



Once the average is recorded on the appropriate QMS density form, press “Enter” to store the data (refer to the following diagram).



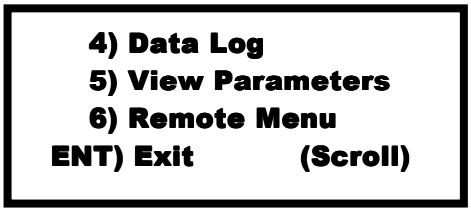
Press “1” and the LCD will display the following:



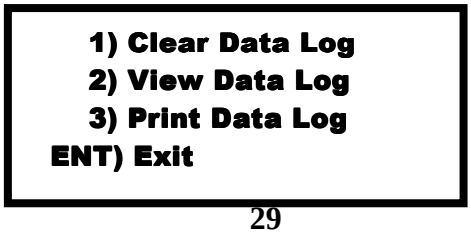
Using the keypad enter the station. For this example enter 300 as the “First #” and press “Enter”. Enter 50 as the “Second #” and press “Enter”.

Printing Data

Once the density readings have been stored in gauge memory the data can be printed. To print data, enter the Setup Menu and select the “Data Log” function by pressing “4”.



Select the “Print Data Log” by pressing “3”. Once the data is printed select the “Clear Data Log” to erase the data.



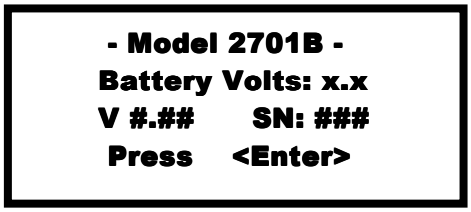
FIELD OPERATION PROCEDURES FOR PAVETRACKER 2701-B

When a new device is puchased the operator should read and become familiar with the manufacturer's operation manual. Knowledge gained from the operator's manual will help to ensure the gauge is operated safely and efficiently.

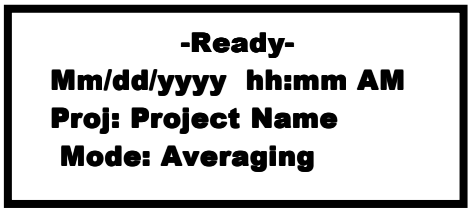
Turning the Gauge "ON"

The gauge uses rechargeable nickel-metal hydride batteries and should be recharged if the voltage falls to 6.0 V. The gauge will automatically power down if the voltage falls below 5.5 V.

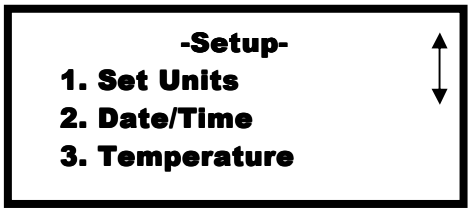
To turn the gauge on press the power switch (next to serial port on front panel). When first turned on, the device will display the following:



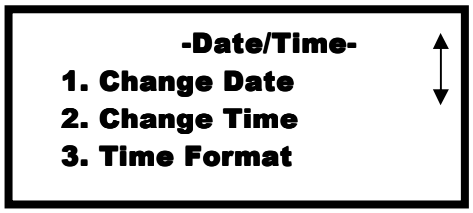
Press "Enter/Start" button on keypad. After press "Enter/Start", the device will perform two self-tests to check for malfunctions. Following the self-tests the gauge will displays the Ready screen.



Since density readings will be stored verify the date and time are correct. To adjust date and/or time press the "Setup" key to access the Setup menu functions. The display will be:



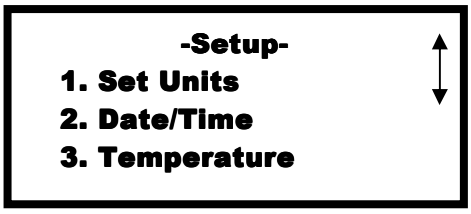
Addition menu functions are listed on the Setup menu as indicted by the double arrow. Use the "arrow" keys to scroll through the functions. Press "2" on the keypad to enter the Date/Time menu and follow the instructions listed on the LCD display.



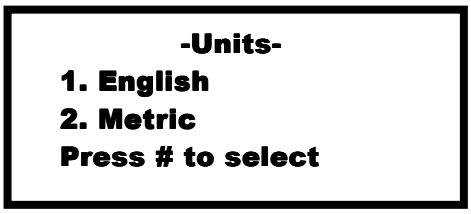
GAUGE PARAMETER SET-UP

Unit Selection

The Pavetracker is display density measurements in either metric or English units. To set the units press “Setup” key to access the setup menu. The LCD will display:



Select “1” for the following display:

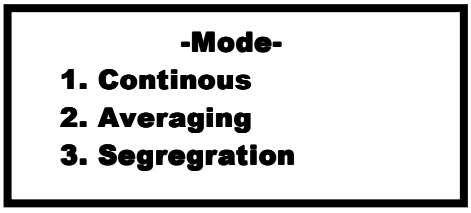


Reference Reading

To ensure accuracy of the gauge, a Reference Reading must be taken each time the gauge is turned on and periodically thoughout the day. All Reference Readings must be taken on a flat smooth surface of the material being tested. Density readings can also be taken on the Reference Standard Block to verify the gauge is reading the standard block within +/- 0.5 pcf. As a minimum a density reading must be taken on the Reference Block just prior to obtaining density readings within the Control Strip and at the beginning of each Test Section. If the gauge exceeds the tolerance (+/- 0.5 pcf) another Reference Reading must be taken. Follow the procedures for performing the Reference Reading provided in the manufacturer’s operators manual. If, after two consecutive Reference Standards, the gauge does not measure the standard block with +/- 0.5 pcf, the device can not be used for density acceptance testing. Contact the manufacturer for additional guidance regarding calibration/repair. Records of calibration must be maintained for verification by Department representatives. Department representatives may request periodic Reference Standard Block density measurements to verify the device is measuring the Reference Standard Block within tolerance.

Measurement Mode Selection

When testing with a Pavetracker Plus device at an individual test site within a Test Section or individual core site within a Control Strip, a total of five measurements will be required at each site. Taking more density measurements reduces variability providing a better representation of HMA density. Increasing the number of density readings is possible due to the short count time required to take a density reading. The Pavertracker displays results in approximately 3 seconds. The Pavertracker also provides an “Average” mode function which averages up to 30 readings. When using the “Average” mode, the average of the five stored density measurements are recorded, printed and submitted with the required QMS density forms to the appropriate QA representative.
To select the measurement mode press the “Mode” key. The display will be:

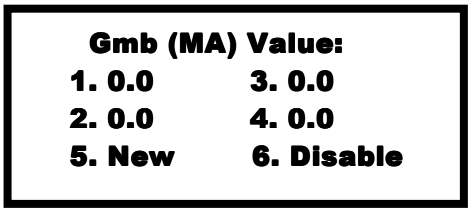


Press “2” to select Averaging mode.

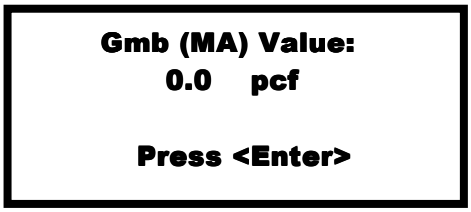
Entering a Target Density

Input the Target Density prior to taking a measurement. Press the “Target” key and the LCD will display:

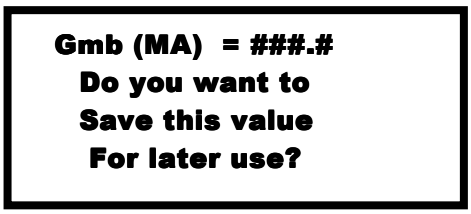
Press “1”



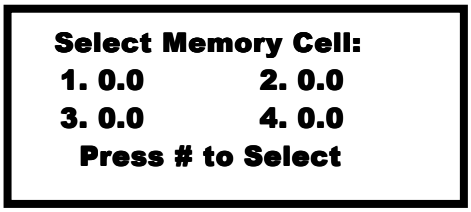
If the desired Target Density has been stored in memory cells 1-4, then select the correct value. If a new Target Density is being entered, press “5”.



Use the keypad and enter the Target Density and then press “Enter”. The screen will display the following:



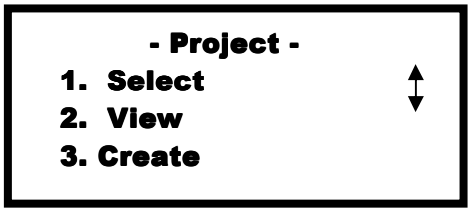
If “No” is pressed the Target Density will remain active in the gauge. If “Yes” is selected the Target Density will remain active and the screen will display the following:



Press the number of the corresponding memory cell to store the Target Density in memory. The Target Density can then be recalled when needed.

Creating a Project

When testing asphalt for acceptance with a gauge, measurements must be recorded on the appropriate QMS form, stored in gauge memory, and printed. All copies of QMS forms along with the gauge printout tapes must be submitted to the QA representative. In order to store any density measurements a Project file must be created. To create a project, press "Proj". The screen will display:



Note that several Project menu functions (i.e. "Select", "Erase", "Create", etc.) are available to manage the project files within the gauge. To create a new project file, press "3". The screen will display:

Enter the primary contract number. For example, if a resurfacing project has a primary contract number of C200001, press "Alpha Lock" then "C" followed by "Alpha Lock" then enter the numbers. Once the contract number is entered press "Enter". The LCD will display:

Select "Yes" on keypad. Once the project is active all mearsurements which are stored will be placed under that particular contract file.

Site Preparation/Gauge Positioning

- Remove any loose material (sand, aggregate, etc.) from the test site.

- If moisture is noticeable on the surface wait for the moisture to evaporate or remove the moisture with an absorbent cloth.

- Ensure the bottom of the gauge is clean and does not “rock” when placed on the mat. The device must remain level and steady. If rocking occurs, find a more suitable test site within a 3 foot radius. When taking measurments around a core the gauge operator may move the gauge 12 inches away from the core location to level the gauge, but the core must be cut from the center of the 5 gauge readings. Refer to the following diagram for a typical Pavetracker test pattern for a core site in a Control Strip and test site within a Test Section.

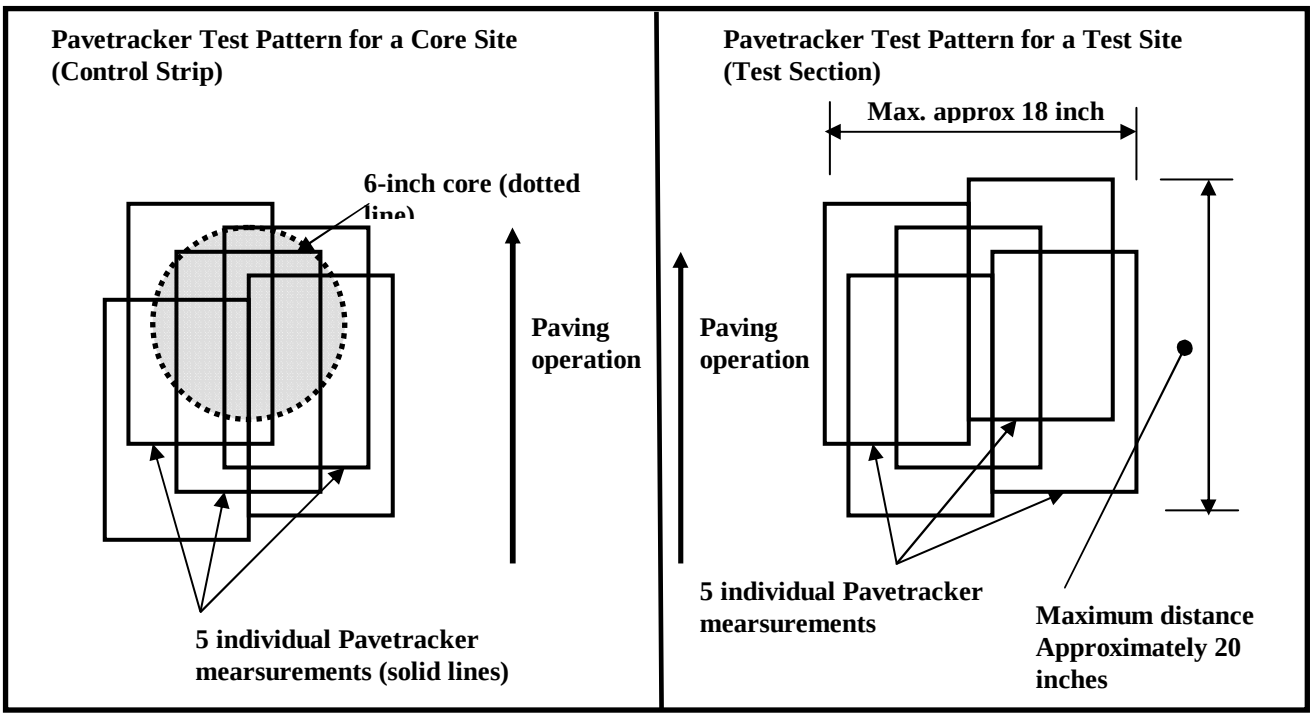


Figure 9

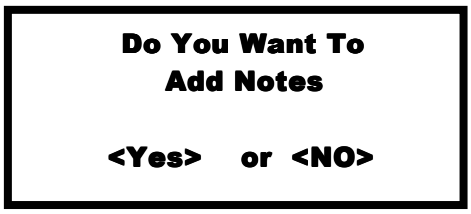
When taking measurements with a Pavetracker, keep the device oriented on the pavement so that it is parallel with the paving operation.

Taking a Density Measurement

Place the gauge on the measurement site as described in the previous section. Press “Enter/Start” and the screen will display:

Averaging Mode
Reading #: 1
Press <Start>
<Store> / <ESC> to End

Press “Enter/Start” again to begin measurement #1. DO NOT TOUCH the gauge as a measurement is being taken. Once the density results are displayed move the gauge over and repeat the same steps to take the next reading. As the readings are taken the gauge will average the results. Once all five measurements are taken, press “Store” The screen will display:

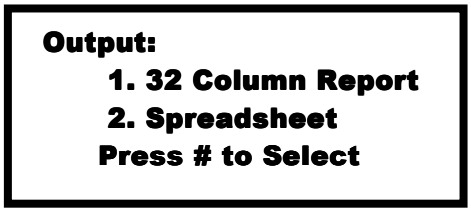


Press “Yes” and use the keypad to enter the station. Once the station is entered press “Enter” to return to the Ready screen.

Printing Data

To print the stored measurement results press “Proj” for the Project menu functions. Select function “5” for Output. The screen will display:

Select desire function. The screen will display:



Connect the serial cable to the 9-pin serial port on the Pavetracker and connect the serial cable to the printer. Select “1” for 32 Column Report. Select “1” to print the report.

Erase Projects

Project files can be erased by pressing “Proj” to enter the Project menu functions. Select “4” to erase a project. As always remain cautious when erasing projects.

FIELD COMPACTION QUALITY MANAGEMENT SYSTEM

QUALITY CONTROL OF DENSITY BY THE CONTRACTOR (QC)

The Contractor shall perform quality control of the compaction process in accordance with applicable provisions of Article 609-5(D). The Contractor may elect to use either cored sample density procedures or nuclear gauge density procedures. When placing surface mixes the Contractor may also elect to use non-nuclear density gauge procedures. Non-nuclear gauges can not be used to test base or intermediate mixes for density acceptance. Non-nuclear gauges currently approved to test surface mixes are Troxler Pavetracker Plus Model 2701-B and TransTech PQI Model 301. The Contractor shall provide the method and frequency of density quality control to the Engineer at the preconstruction conference.

Nuclear or non-nuclear density control shall be in accordance with the procedures outlined in this manual. Nuclear density shall be determined by the backscatter method of testing using a nuclear gauge with thin-lift and printer capabilities, which has been approved by the Department. The Contractor shall furnish, maintain, and operate the density gauge. The density gauge operator shall have been certified by the Department. The density gauge shall have been calibrated within the previous 12 months by a calibration service approved by the Department. The Contractor shall maintain documentation of such calibration for a 12-month period.

All density gauge readings taken for either density acceptance or establishment of a target density in a control strip must include:

- Recording density results on the appropriate QMS form(s) (record the average of 5 readings if using a non-nuclear gauge)
- "Storing" gauge density measurements in gauge memory
- Printing density measurements stored in gauge memory
- Providing gauge printouts and appropriate QMS form(s) to the QA representative

All density measurements taken with a density gauge must be marked on the pavement by tracing the "foot print" of the device. If an area is re-rolled, the test site must be re-tested and a comment placed on the test report as to the reason. Any repeated moving of any density gauge to "cherry pick" or find a passing density result or core site is a direct violation of testing procedures and could be deemed as falsification. For resurfacing projects where conditions of the existing pavement may influence the density results, it is recommended that the Contractor and Engineer simultaneously evaluate the existing pavement prior to the placement of a new asphalt mix. The information recorded from the evaluation can aid in the final acceptance process.

The minimum frequency of sampling and testing shall be on the basis of test sections consisting of not more than 2000 linear feet (600 linear meters) or fraction thereof per day, on pavement placed at the paver laydown width. Do not divide full test sections, consisting of 2000 linear feet (600 linear meters), unless otherwise approved by the Engineer. As an exception, when a day's production is less than 6,000 linear feet of laydown width, the total length paved may be divided into 3 equal test sections, provided that nuclear testing has not already occurred or core sample locations established. Nuclear or non-nuclear gauge readings taken for density acceptance or establishment of a control strip must be taken after the finish (or final) roller has completed the compaction operation. If the fraction of a test section remaining at the end of a day is less than 100 linear feet (30 linear meters), it is recommended that the density be represented by the results of the previous section provided the approved compaction equipment and procedures are used. If the fraction remaining is at least 100 linear feet (30 linear meters), it will be considered a separate test section and shall be sampled and tested accordingly. When utilizing a nuclear gauge, the testing frequency shall consist of five random

gauge readings (one random reading from each of five (5) equally spaced increments) from each test section. In addition, not less than five (5) nuclear gauge readings (one test section) shall be taken from any acceptance lot of a given mix type. When utilizing a non-nuclear gauge, the testing frequency shall consist of five randomly located test sites from each test section. Five individual gauge readings will be taken at each test site and the results will be averaged to determine the percent compaction. Only the average of the five non-nuclear gauge readings will be recorded on the appropriate QMS form and stored in gauge memory for printing. In addition, not less than one test section (25 non-nuclear gauge readings) shall be taken from any acceptance lot of a given mix type.

Sample and test all pavements that meet the following criteria unless otherwise approved.

1. All full width travel lane pavements, including:
   a. Normal mainline and -Y- line travel lane pavements
   b. -Y- line travel lane pavements of uniform thickness in intersections
   c. Turn lanes
   d. Collector lanes
   e. Ramps and loops
   f. Temporary pavements
2. Pavement widening 4.0 feet (1.2 meters) or greater
3. Uniform width paved shoulders **2.0 feet** or greater

For all mix types that meet the following criteria, a specified density will not be required provided the pavement is compacted using approved equipment and procedures. The Engineer may require occasional density sampling and testing to evaluate the compaction process. Densities lower than specified will be evaluated in accordance with Article 105-3.

1. Pavement widening of four (4) feet (1.2 meters) or less, Bases and intermediate mixes **(surface mix types not included)**.

2. Pavement used in intersections, all mix types used in intersections **(exclusive of full width travel lanes of uniform thickness)**

3. Pavement used in tapers and irregular areas which have shapes that may make them difficult to compact. **This applies to all mix types.**

The Contractor shall maintain minimum test frequencies as established above. Should the Contractor's density testing frequency fail to meet the minimum frequency as specified above, all mix without required density test representation shall be considered unsatisfactory and if allowed to remain in place, will be paid for in accordance with Article 105-3 of the Standard Specifications.

QC nuclear or non-nuclear density tests shall be conducted the same day that the mix being tested was placed and compacted. Should the specified density tests not be completed within the applicable time frame, production will cease at that point until such time the required tests are completed.

CONTRACTOR'S CONTROL STRIP PROCEDURES (QC)

Location

It is the Contractor's responsibility to determine roller patterns and establish acceptable control strips at locations approved by the Engineer. The Contractor shall notify the Department's Roadway Inspector sufficiently in advance of the placement of control strips to allow establishment of QA target density and to witness the QC technician's Standard Count Procedure. The subgrade, base or existing roadway material on which the control strip is constructed must be representative of the majority of material where the test sections will be constructed.

Frequency (Control Strips)

A control strip shall be placed within the first test section of each job mix formula on a contract provided sufficent mix is produced to construct a 300 foot control strip. After the initial control strip on each job mix formula is placed, a control strip shall be placed at a minimum of every 14 calendar days. A control strip placed for any of the below listed reasons will suffice for this requirement.

1. Control strips shall be placed anytime one or more of the following JMF changes are made:
   a. Any percentage change in binder content
   b. An aggregate blend change in excess of +/-10%
   c. Any change in G_{mb} or G_{mm} on the JMF

2. Control strips shall be placed for each layer of mix.

3. Control strips shall be placed anytime the underlying surface changes significantly.

4. Control strips shall be placed for different layer thickness of the same type mix when the specified thickness varies more than +/- ½ of an inch (12.5 millimeters).

5. Control strips shall be placed anytime the Contractor is proceeding on a limited production basis due to failing densities.

6. Control strips shall be placed anytime a new, re-calibrated, or different density gauge is initially used.

7. Control strips shall be placed if a different plant is used.

8. The Engineer may require control strips anytime he/she deems necessary.

Mix Sampling Requirements for Control Strips

Quality control mix sampling and testing shall be performed on the mix in accordance with Subarticle 609-5 (C)2 of the Specifications, except when placing mix on a limited production basis due to failing densities. In this case, a full test series shall be performed on the actual mix placed in each control strip. When a mix sample is required to be taken in conjunction with a control strip, that sample will not substitute for the next randomly scheduled QC mix sample for that tonnage increment. Subsequent QC mix samples will be taken at tonnages in accordance with normal random sampling procedures. When placing mix on a limited production basis, the contractor's QC plant personnel will notify Roadway personnel as to which truck the sample was taken from. The notification method will be at the Contractor's option (Radio, telephone, and note on load ticket, etc.)

Numbering (Control Strips)

1. Control strips for a given contract shall be numbered consecutively by type mix, regardless of plant furnishing the mix. However, if a control strip is made for mix out of a second plant, the number for this control strip will be followed by the suffix A -- a third plant control strip would be followed by a B, etc. For example: 1st plant C.S. would be 1, 2, 3; 2nd plant C.S. would be 4A, 5A, 6A; 3rd plant C.S. would be 7B, 8B, etc.

2. Each type mix will have a separate series of control strip numbers.

3. Both passing and failing control strips will be numbered and reported to the Engineer.

4. If a secondary gauge is used on a control strip for back-up purposes, the secondary gauge control strip will be numbered with the same numbers as used for the primary gauge except that it will be followed by the suffix "S".

Establishment of Control Strip (QC Procedures)

To establish a control strip, asphalt shall be placed on a section of roadway approximately 300 feet (100 meters) in length. The width shall be equal to the lay-down width of the paver. The material should be of a depth equivalent to the layer depth shown in the plans or required by the Specifications. The Engineer may determine that the control strip is representative of the shoulders and that the control strip may be used to determine the required density for the shoulders. If shoulder control strips are constructed, they should be constructed to the full shoulder width and the depth shown on the plans.

The density obtained on the control strip determines the density required for that layer until the next control strip is constructed. It is, therefore, very important that the compaction equipment used on the control strip is operating properly and is capable of compacting the material. The same equipment should be used to compact the pavement after the control strip is compacted. Reference should be made to the applicable sections of the Specifications for minimum equipment requirements.

In order to achieve a complete and uniform coverage, the compactive effort shall consist of roller passes made over the entire control strip surface. Breakdown rolling shall be performed at the maximum temperature at which the mix will support the rollers without moving horizontally. The breakdown roller should normally be operated with the drive wheel nearest the paver. The Contractor will be responsible for carrying out the compaction operation in such a manner as to obtain the required density uniformly over the entire control strip. The compaction rolling shall be completed prior to the mixture cooling below a workable temperature.

In order to ensure complete and uniform coverage, the compactive effort shall consist of individual roller passes made over the entire control strip surface. Each coverage should be completed before beginning the next. The density gauge operator should observe the rolling operation to ensure that the control strip is rolled uniformly. The random locations of core samples from the control strip will not be marked on the pavement until the compaction operation in the control strip has been satisfactorily completed. Cores within a control strip shall be cut and removed prior to opening that section to traffic.

Control Strip Core Samples

1. Five (5) core samples shall be taken in a control strip. If a core is damaged, follow procedures for check cores.

2. Core samples in the control strip shall be placed a distance of fifty 50 feet (15 meters) apart.

3. Core samples shall be located randomly across the width of the mat.

NOTE: The results of the cored samples and their average will be reported at the top of M&T Form 514QA/QC.

Numbering Core Samples From a Control Strip

Core samples from control strips will be numbered according to guidelines for numbering all core samples. The letters "QC" will follow all sample numbers.

When placing two mix types on the same project, core samples will be numbered as follows:

I 19.0B 1st Control Strip (core samples) 1QC, 2QC, 3QC, 4QC, 5QC; 2nd Control Strip (core samples) 6QC, 7QC, 8QC, 9QC, 10QC, etc.

S 9.5A 1st Control Strip (core samples) 1QC, 2QC, 3QC, 4QC, 5QC; 2nd Control Strip (core samples) 6QC, 7QC, 8QC, 9QC, 10QC, etc.

Procedures for Checking Core Samples From a Control Strip

Check core samples may be taken by the Contractor for either of the following reasons:

1. When a control strip fails and a core sample(s) is more than 2.0 percent below the average of the control strip, that core(s) may be checked.

2. One of the original core(s) is damaged.

For each core sample that is to be checked, take 3 check samples as follows: one adjacent to the initial sample and one ten feet (3 meters) in each direction, longitudinally, of the initial sample. The results of these 3 check samples will be averaged and this average will be used in lieu of the initial core results in question. The initial core samples will not be used if check samples are taken. Check samples must be taken within 2 calendar days of the initial sample. Only one set of check samples per sample location will be allowed. The separation of the layer to be tested will be the responsibility of the Contractor. Take all check samples in the presence of a representative of the Engineer. In addition, a QA comparison core sample(s) may be taken adjacent to one or more of the check samples. To establish the control strip, 2 nuclear gauge readings must also be taken at each of the 3 check sample core sites. The gauge readings taken on the left side of each check core will be averaged and will replace the left gauge reading taken at the original core site. The same procedure will be followed for the gauge readings taken on the right. The results from the 3 check cores and 6 gauge readings will be used to calculate the target density. If using a non-nuclear gauge for density acceptance testing, 5 gauge readings will be taken at each of the 3 check sample core sites. The non-nuclear gauge measurements taken at each check core site will replace the original core site measurements. The

results from the 3 check cores and 15 non-nuclear gauge readings will be used to calculate the target density.

Numbering Quality Control Check Core Samples

The specifications allow check samples adjacent to the original core and 10 feet (3 meters) longitudinally each side of the original core.

All check samples will carry the same base number as the original core sample followed by a C_1, C_2, and C_3 series of suffixes.

Example: If core number 8 is in question, the check core sample will be:
$8C_1$ (10' / 3m down station), $8C_2$ (adjacent), and $8C_3$ (10' / 3 m up station)

Retention of Control Strip Core Samples

The Contractor's control strip core samples shall be retained for five (5) calendar days at the plant site or until disposal permission is granted by the quality assurance personnel, whichever occurs first. The QA personnel will retest 100% of the control strip cores. The Department's comparison quality assurance core samples shall be retained in a sealed container at the plant site until obtained by quality assurance personnel. All retained samples shall be stored on a smooth, flat surface in a cool, dry protected location.

QC Target Density

Before establishing the QC target density, the QA Roadway Inspector and/or the QA nuclear gauge operator will witness the Standard Count procedure for the QC nuclear gauge(s). Likewise, the QC nuclear gauge technician will witness the Standard Count procedure for QA nuclear gauges. If the standard counts pass, these Standard Counts will be recorded on the M&T 514QA/QC form. It is not necessary to perform another daily standard count specifically for a control strip, so long as the Department witnessed the QC standard count that day and the materials, and underlying base have not changed.

After the Contractor has completed compaction of the control strip, the QC Density Gauge Operator will conduct ten (10) nuclear gauge density tests, two (2) readings at each of the five (5) random core locations in the control strip. The nuclear gauge readings shall be performed directly on the core site (refer to Figures 4 or 7). Do not move the nuclear gauge in between each measurement. When testing with a non-nuclear gauge, the density gauge operator will conduct twenty-five (25) non-nuclear gauge density tests, five (5) readings at each of the five (5) random core locations within the control strip. The surface of the material being tested shall be smooth prior to any tests being performed. The results of the gauge measurements will be averaged and the resulting average density will be used in determining the target density for all test sections being constructed in conjunction with a particular control strip. The target density will be determined by dividing the average density by the average percent compaction of the five (5) core samples from the control strip. Test section densities will be expressed as a percentage of the target density.

The final density of the control strip shall be at least equal to the minimum density specified for the mix based on the maximum specific gravity (G_{mm}). In addition to determining the target density, the

following procedures and tests will be performed to assure that the final density of the control strip meets the minimum density requirements:

1. Prior to opening the control strip area to traffic or no later than the beginning of the next day following the completion of the control strip, the Contractor shall core five (5) samples from the control strip. The density of each cored sample will be determined in the QC field laboratory. Artificial cooling of the pavement layers by the Contractor will be permitted in order to obtain cored samples as quickly as possible. No compensation will be made for the cost of artificial cooling. Cored samples shall be taken in accordance with Subarticle 609-5(D).

2. During the time between the completion of the control strip and the determination of the density of the cored samples, the Contractor will be permitted to continue to place pavement which will be evaluated on the basis of a calculated target density determined by multiplying the unit weight of water (62.4 pcf) by the maximum specific gravity of the mix. Evaluation of the test sections during this time period will be based on this calculated target density, provided all other specification requirements are met. Once an acceptable correlated target is established, all previous test section densities shall be re-calculated using this correlated target.

3. If the average density of the five (5) cored samples is at least equal to the minimum density specified for the mix, the control strip is considered valid and paving may continue in the normal manner.

4. If the average density of the five (5) cored samples fails to meet the minimum density, specified for the mix, the control strip will be considered unacceptable. The Contractor shall immediately construct a new control strip in accordance with the provisions of Items 1 through 3 above.

5. If the second control strip also fails to meet the minimum density specified for the mix, placing of pavement shall proceed on limited production basis as defined under "LIMITED PRODUCTION PROCEDURES" in Section 10-10 of the current HMA/QMS Manual.

6. Check samples may be taken on any control strip core samples, but must be in accordance with "Procedures for Checking Core Samples from a Control Strip" as previously described in this manual (Subarticle 609-5(D)1 of the Specifications). A new target density will then be determined using the new core sample average and the new average of the gauge readings. This process should be completed as soon as possible after the initial determination of a target density since it is the controlling factor in checking density thereafter.

7. Once a correlated target density is established, it will be used thereafter to determine density acceptance until a new acceptable target is obtained for that mix. For control strips required every 14 days, all mixed placed the same day as the control strip will be accepted based on the target density established in that control strip. Once the density results of the cored samples from the new control strip are determined and a new acceptable target density established, the new target will be used to determine acceptance for that mix placed during the day's production thereafter until another 14 calendar day control strip is required, at which time this process is repeated.

8. If more than 17 calendar days have lapsed since last using a correlated target density, the procedures for obtaining a new correlated target, as detailed in Items 1-7 above, shall be followed.

However, the current maximum specific gravity moving average will be utilized to determine the calculated target instead of the JMF maximum specific gravity.

QC/QA Nuclear Density Control Strip Procedure

10 Nuclear Gauge Readings (2 @ 5 core locations) will be taken within the 300’ (100m) control strip.
5 Core Samples will be taken at 50’ (15m) intervals, randomly across the width within the 300’ control strip

All gauge operators (QC/QA) shall be approved by the NCDOT.

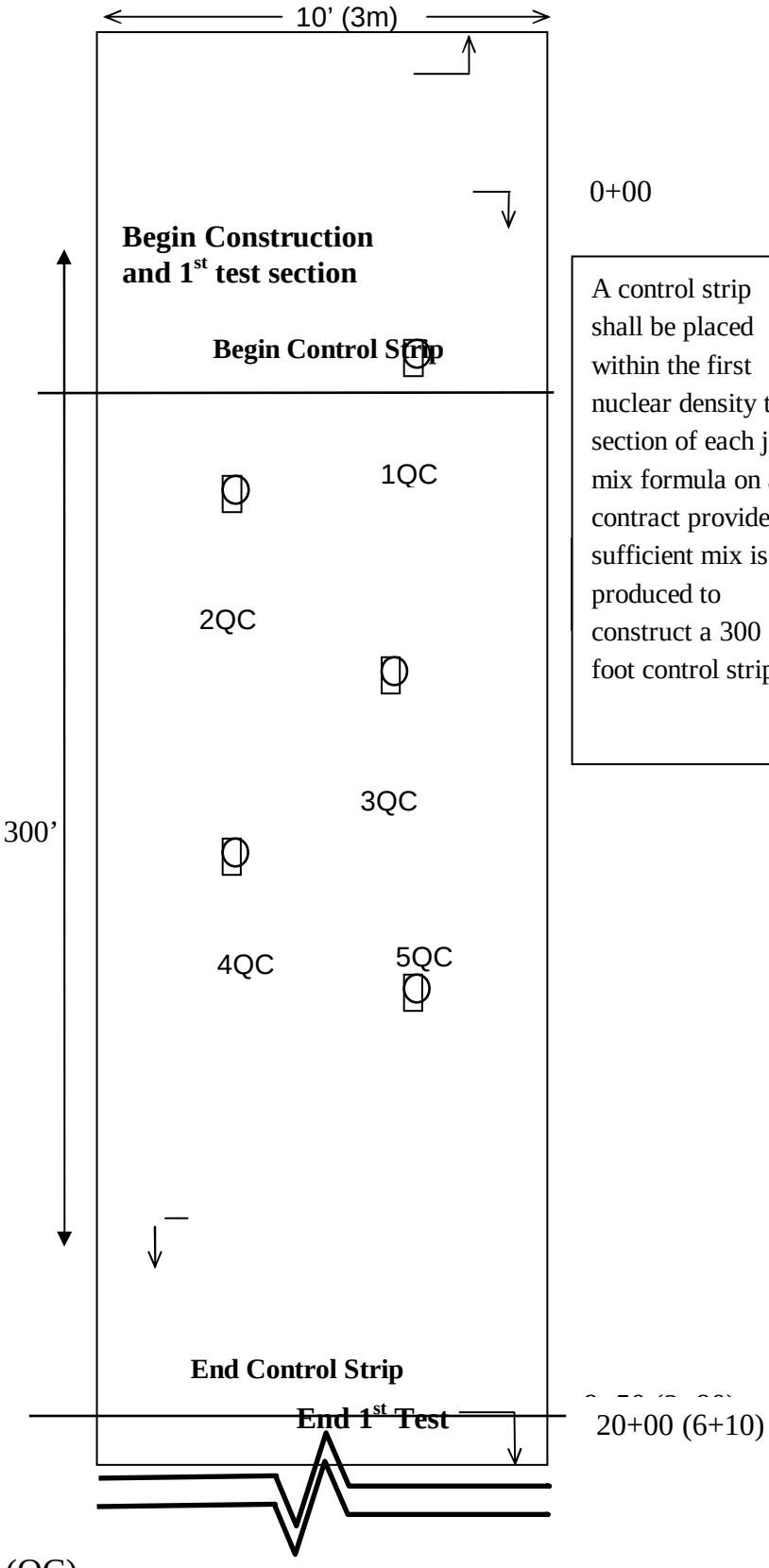
QC gauge operator shall confirm with the DOT Roadway Inspector on when and where the control strips will be placed.

The DOT Roadway Inspector shall inform the QA Supervisor and/or the QA nuclear gauge operator of the control strip placement.

The QA Roadway Inspector and/or the QA Nuclear gauge operator will witness the Standard Count procedure for the QC nuclear gauge(s). Likewise, the QC Nuclear gauge technician will witness the Standard Count procedure for QA nuclear gauges. These Standard Counts will be recorded on the M&T 514QA/QC form.

Two nuclear gauge readings will be taken at each core sample site. The nuclear gauge readings shall be performed directly on the core site. The nuclear readings shall be compared to the core sample results and a nuclear target density shall be determined using the M&T 514 QA/QC form.

QA Personnel will establish their own target density from control strip results, if possible. If it is not possible to take QA readings from the control strip, the QA target density will be determined by multiplying the appropriate Specific Gravity (Gmm) times 62.4 lbs/c.f. (1000 kg/m^3)



A control strip shall be placed within the first nuclear density test section of each job mix formula on a contract provided sufficient mix is produced to construct a 300 foot control strip.

= QC and/or QA Nuclear reading
= Core Sample (5 core samples per control strip)

TEST SECTION PROCEDURES (QC)

Establishment of Test Sections

A test section is the testing unit for compaction. The lengths of these test sections shall be no more than 2000 linear feet (600 meters) or fraction thereof per day on pavement placed. If the fraction of a test section remaining at the end of a day is less than 100 linear feet (30 linear meters), it is recommended that the density be represented by the results of the previous section provided the approved compaction equipment and procedures are used. The width of the test sections shall be the same as the paver laydown width. The first test section will begin with the first load of each type mix on each contract.

Test sections will be checked for acceptance as prescribed. The material used in a test section shall be from the same source and shall be of the same type as the material used in the applicable control strip. The depth of a test section shall be equal (+/- ½) to that of the control strip previously constructed for use with the test section involved except in cases where roadway control strips are used to determine required density for shoulder material.

Testing a Test Section

The test sections shall be divided into five (5) equal segments each from which one test site is to be located. The location of the test site within the segment is to be at random. Do not identify, mark or take acceptance measurements on the test site until the final or finish roller has completed the compaction operation. Refer to the instructions for random sampling in this manual.

Before testing begins with a nuclear gauge, the daily standard count should be compared to the standard count used to construct the active control strip. The daily standard count should be within the allowable Standard Count Range. The upper range limit is calculated by taking the standard count used for the construction of the active control strip and adding 1%. Likewise, the lower range limit is calculated by subtracting 1% from the standard count used to construct the active control strip. This allowable range is computed and recorded on the M&T – 514QA/QC form.

As long as the daily standard count passes the system 1 and system 2 requirements of the gauge and is within the allowable Standard Count Range for the active control strip, testing may be performed. However, if either the daily standard count does not pass the system 1 and system 2 requirements, or if the standard count is outside of the allowable Standard Count Range from the active control strip, then another standard count must be taken until it passes all criteria.

Once the daily standard count is accepted and test locations have been determined, a nuclear density test will be taken at each site. If a non-nuclear gauge is being used 5 density measurements will be taken at each test site and the average of the five readings will determine the density for that particular test site and recorded on the appropriate form. Refer to Figure 8 in this manual for the testing pattern of a PQI 301 gauge and Figure 9 for the testing pattern of a Pavetracker Plus 2701B gauge. The results shall be in % compaction, tabulated on Test Section Density Form M&T 516QC and the five test sites averaged.

Testing full width travel lanes in an intersection (exclusive of mainline pavement) will be performed by using the correlated target density established on the mainline pavement. All combined intersection travel lanes paved during a day's production shall be considered a test section for testing purposes and a lot for acceptance purposes. Each lot established for intersections shall have 5 randomly selected test sites. If in the opinion of the Engineer, the pavement in an intersection is not representative of the mainline pavement, a specified density will not be required provided the Contractor is using equipment

and procedures approved by the Engineer. The Engineer may require occasional density sampling and testing to evaluate the compaction process.

Numbering Test Sections

Asphalt test sections will have a separate series of numbers for each type mix per paving operation for each contract. Test sections for a given contract shall be numbered consecutively by type mix, regardless of plant furnishing mix. When the Contractor has more than one crew placing the same mix on the same project, the test section numbering will run consecutively. If more than one paving crew is placing the same mix designate a crew number and maintain that designation throughout the entire paving project. The crew designation should be indicated on the QMS Forms: 514 QA/QC, 515 QA, and 516 QC.

Test Section Requirements

Unless otherwise specified in the contract, the required density for all superpave mixes shall be as follows:

Type Mix	Maximum Specific Gravity (AASHTO T-209)
B 25.0	92.0
I 19.0	92.0
S 12.5 & S 9.5	92.0
SF 9.5A	90.0
S 4.75A	85.0 [(a,b)]

(a) All S 4.75A pavement will be accepted for density in accordance with Article 105-3

(b) Compaction to the above specified density will be required when the S 4.75A mix is applied at a rate of 100 lbs/sy (55 kg/m^2)

The actual test section density will be determined by the average of five (5) nuclear density tests made at random locations within five (5) equal segments of the test section. If using a non-nuclear gauge the actual test section density will be determined by the average of twenty-five (25) non-nuclear density tests made at random locations with the five (5) equal segment of the test section. This actual density will be compared to the target density to determine compliance.

If the average fails to meet the above requirements, the test section will initially be considered as failed, but additional rolling may be performed by the Contractor. A note should be made to the effect that this section was re-rolled. In this case, acceptance of the test section will be based on the average after re-rolling.

If the QC test results indicate failing density of the mix based on the calculated target, that mix may be subject to pay reduction or removal in accordance with the provisions of Section 610-13 of the Specifications. Once the correlated target density is determined and if the recomputed densities still indicate that the mix fails to meet the requirements specified in Section 610-13 of the Specifications, it will be subject to pay reduction or removal. If the recomputed densities indicate passing results, the mix will be accepted as passing.

Procedures for Re-testing a Nuclear or Non-nuclear Test Section

When nuclear or non-nuclear control is being utilized and a test section is more than 2.0 percent below the lot average, the Contractor may elect to re-test that test section.

All re-testing shall be performed in the presence of a representative of the Engineer. The re-testing of test sections must be performed within 2 calendar days of the date of the initial sample. A test section will only be re-tested once. In addition, QA comparison nuclear or non-nuclear density readings may be taken at all locations.
Re-testing of test sections will be performed as follows:

1.) 5 new random test sites will be determined jointly with a representative of the Engineer.
2.) All re-test readings must be stored and printed
3.) The average of these 5 new nuclear readings or 25 new non-nuclear readings will replace the initial test section results.
4.) The lot average will be recalculated.

DENSITY LIMITED PRODUCTION PROCEDURES

The Contractor shall operate on a limited production basis if, for the same mix type, one of the following items occurs.

1. Two consecutive failing lots, excluding lots representing an individual resurfacing map or portion thereof.

2. Three consecutive failing lots, with each lot representing an individual resurfacing map or portion thereof.

3. Two consecutive failing control strips.

Pavement within each construction category (New and Other), as defined in Article 610-13, and pavement placed simultaneously by multiple paving crews will be evaluated independently for limited production purposes.

Once the Contractor is placed on limited production he shall remain on limited production for that mix type regardless of the plant or JMF. As an exception, the Engineer may grant approval to produce a different mix design of the same mix type if Quality Control and Quality Assurance plant mix test indicate the failing densities are attributed to the mix problem(s) rather than compaction related problems. The determination of whether a mix problem exists at this time made by QA personnel (normally the QA Supervisor).

Limited production is defined as the production, placement and compaction of a sufficient quantity of mix to construct a 300-ft. control strip plus 100 ft. of pavement adjacent to each end of the control strip.
The contractor shall remain on limited production until such time as satisfactory density results are attained or two control strips have been attempted without achieving acceptable density test results, whichever occurs first. Should the contractor fail to achieve satisfactory density at this point,

production of that mix type shall cease until such time as the cause of the failing density test results can be determined. As an exception, if there are mix property problem(s) at the same time that limited production occurs due to failing densities, the Contractor may elect to produce a different mix design of the same mix type. The determination of whether a mix problem exists at this time will be made by the QA Supervisor.

When proceeding on limited production due to failing density, the 500 feet of pavement, which includes the control strip, will be considered a lot. The average density of the five control strip cores will be used as the density result for acceptance of that lot in accordance with Article 610-13.

Should the Contractor not operate by the limited production procedures as specified above, the failing lots and all mix produced thereafter will be considered unacceptable. This material shall be removed and replaced with material, which complies with the specifications. The final in-place materials will be accepted in accordance with article 105-3.

QUALITY ASSURANCE OF DENSITY

Quality Assurance is a process of sampling and/or testing the Contractor's product and monitoring his operations to confirm that the Quality Control results are adequate and accurate. The Department shall provide a certified gauge operator for this purpose.

Quality Assurance testing shall be accomplished in the following ways:

1) Re-testing randomly selected quality control (QA test) nuclear or non-nuclear test sections at a frequency equal to or greater than **5%** of the required Quality Control density gauge testing frequency;
2) Periodically observing tests performed by the Contractor;
3) Conducting verification testing ("V" test) on nuclear or non-nuclear test sections at different random locations within the same QC test sections, at a frequency of at least **10%** of the required QC sampling and testing frequency;
4) By periodically directing the recalculation of random numbers for the Quality Control density gauge test locations. The original QC test locations may be tested by QA and evaluated as verification tests;
5) Periodically requiring the Contractor to retest marked test site(s) in the presence of a certified QA gauge operator;
6) Witnessing the daily quality control nuclear gauge Standard Count procedure;
7) Witnessing the Pavetracker 2701B Reference Count;
8) Requesting the QC to take a density reading on the Reference Block to verify Pavetracker is measuring correctly
9) Witnessing the PQI Test Block Procedure;
10) Verifying PQI Test Block results are within tolerance
11) Retesting 100% of all nuclear or non-nuclear control strip cores; or
12) Any combination of the above.

QA Nuclear or Non-nuclear Control Strip Procedures

There will be no separate QA Nuclear or non-nuclear Control Strips constructed unless directed by the Engineer. The Engineer will monitor the construction of all QC nuclear or non-nuclear control strips by having a representative present during construction of all control strips. The Contractor, subject to the Engineer's approval, will determine the location of a control strip and the core samples within it.

When the control strip is used to establish a target density, the Quality Assurance gauge operator will conduct ten (10) nuclear density tests, two (2) each at five (5) core locations in the control strip. The results of the ten (10) tests will be averaged and the resulting average density will be used in determining the target density for all test sections being tested in conjunction with a particular control strip. When testing with a non-nuclear gauge, the QA gauge operator will conduct twenty-five (25) non-nuclear gauge density tests, five (5) readings at each of the five (5) random core locations within the control strip. The target density will be determined by dividing the average density by the average percent compaction of the five (5) core samples from the control strip.

The Engineer may elect to take QA comparison core samples adjacent to any or all QC core samples within a control strip.

If for whatever reason, the Engineer cannot determine a target by taking the ten (10) nuclear gauge readings from a control strip, he may elect to determine a QA target density by use of the maximum specific gravity. In this case, the target density will be determined by multiplying the maximum specific gravity by the unit weight of water (62.4 lbs/ft^3). This method can not be used when testing with a non-nuclear gauge. Non-nuclear gauges must be calibrated to the mix by establishing a target density from a control strip.

Test section densities will be expressed as a percentage of the target density. The QA control strip shall have the same number as the QC control strip with the addition of the suffix QA.

QA Test Section Procedures

The Department's Quality Assurance Gauge Operator will randomly select quality control test sections at a frequency of 5% or more of the same sections tested by the contractor. The location of the test within each of the 5 equal segments will be at the same random QC test location. The QA test sections will have the same base number as the QC test sections followed by the suffix QA. The results shall be recorded in percent, tabulated on test section density form M&T 515QA and the five (5) test sites averaged.

QA Density Verification Testing

Verification testing is an integral part of the Department's quality assurance process. It is independent testing performed by the QA personnel to help assure the asphalt mat is adequately compacted. Listed next are the Department's current guidelines on verification testing for density control. It is very important that all personnel involved with the QMS density testing procedures on asphalt pavements are knowledgeable of these requirements and guidelines. Should these test results vary considerably from the Contractor's QC results or fall below the minimum specification acceptance limit, further testing may be directed by the Department which then could be used as part of the acceptance process.

Roadway Density Nuclear or Non-Nuclear Gauge Procedures

a) The verification requirement will be satisfied by the Department's nuclear gauge operator assuring that at least 10% of the required number of Quality Control test sections are tested by determining a new set of random sample locations other than those used by the QC gauge operator. All verification same numbers and random locations will be documented in a field book by the QA gauge operator. Refer to Section 10 of the HMA/QMS Manual for an example.
b) These verification test sections will be in addition to the minimum 5% required QA samples.
c) Verification test sections will be numbered by the DOT density gauge operator. These verification test sections will be at random locations within the same test section as the QC test section. Verification test sections will be numbered by using the same base as the QC test section followed by the suffix "V". ie 1V, 5V, 10V, etc.
When the Contractor has more than one paving crew on the same project the same day, using nuclear or non-nuclear density control, verification samples will have the same base number as the QC test section followed by the suffix "V". Designated the crew number of the paving crew and list the information and the appropriate QMS forms. Documentation of these verification test sections will be on the appropriate QMS nuclear or non-nuclear density forms. These forms shall be maintained in the project files by the Resident Engineer.
d) In addition to the above, random cores will be taken monthly by the IAS section of the Materials and Tests Unit, except on projects "open" to traffic, on which random control strip core samples will be picked up by IAS for comparison testing by the Materials and Tests Unit.

Differences between the Contractor's quality control and the Department's quality assurance test results will be considered acceptable if within the following limits of precision.

Test	Acceptable Limits of Precision
Gauge Comparison of QC Test Section (average of tests in test section)	+/- 2.0% (percent compaction)
Retest of QC Control Strip Core Sample	+/- 1.2% (percent compaction)

In the event test results are outside the above acceptable limits of precision, or the quality assurance test results are below the minimum specification requirements, the Engineer will immediately investigate the reason for the difference. If the potential for a pavement failure is present, the Engineer may suspend production as stated in Article 108-7 of the Standard Specifications while the investigation is in progress. The Engineer's investigation may include checking of the Contractor's testing equipment, comparison testing of other quality control tests, or additional testing of the roadway pavement in question. If additional tests are necessary to resolve the difference, these tests will be performed jointly by the Contractor's quality control and the Department's quality assurance personnel. If the reason for the difference cannot be determined, payment for the mix in question will be determined in accordance with Article 105-3 of the Standard Specifications. If the reason for the difference is determined to be an error or other discrepancy in the quality control test results, the applicable quality assurance test results will be used to determine compliance with the Specification density requirements.

ACCEPTANCE OF DENSITY

The Department will evaluate the asphalt pavement for density compliance after the asphalt mix has been placed and compacted using the Contractor's quality control test results, the Department's quality assurance test results, including verification samples, and by observation of the Contractor's density quality control process conducted in accordance with Section 609. Minimum density requirements for all mixes will be as specified in Article 610-10, Table 610-4. Density acceptance will be as provided herein. Core sample densities will be determined by use of the average maximum specific gravity (G_{mm}), until a moving average of the last four maximum specific gravities is attained. Once a moving average of the the last four maximum specific gravities is established, the last G_{mm} moving average in effect at the end of the same day's production will then be used to determine density acceptance.

The pavement will be accepted for density on a lot by lot basis. A lot will consist of one day's production of a given job mix formula on a contact. As an exception, separate lots will be established when one of the following occurs:

1) Portions of JMF placed on a given day in both "New" and "Other" construction categories as defined below. A lot will be established for the portion of the pavement in the "New" construction category and a separate lot for the portion of pavement in the "Other" construction category.

2) Pavement is being placed on multiple resurfacing maps, unless otherwise approved prior to paving. A lot will be established for each individual resurfacing map or portion thereof, unless otherwise approved.

3) Pavement is being placed simultaneously by multiple paving crews. A lot will be established for the pavement placed by each crew.

4) Pavement is being placed for intersections

5) Portions of the JMF placed in different layers

6) Control Strip are placed during limited production

The Engineer will determine the final category and quantity of each lot for acceptance purposes.

The "New" construction category will be defined as pavements of uniform thickness, exclusive of irregular areas, meeting <u>all three</u> of the following criteria:

1) Pavement placed on a new aggregate or soil base compacted to the specified density or pavement placed on a new asphalt mix layer (excluding wedging and leveling);

2) pavement which is within a designated travel lane of the final traffie pattern; <u>and</u>

3) pavement which is 4.0 feet (1.2 meters) or wider.

As an exception, when the first layer of mix is placed on an unprimed aggregate base, the layer will be included in the "Other" construction category.

The "Other" construction category will include all pavement except as described above.

A failing lot for density acceptance purposes is defined as a lot which the average of all test sections fails to meet the minimum specification requirement. In addition, any lot or portion of a lot that is obviously unacceptable will be rejected for use in the work.

If the Engineer determines that a given lot of mix which falls in the "New" category does not meet the minimum specification requirements, but the work is reasonably acceptable, the lot will be accepted at a reduced pay factor in accordance with the following formula. The reduced pay factor will apply only to the mix unit price.

$$PF = 100 - 10(D)^{1.465}$$

where:

PF = Pay Factor (computed to 0.1%)
D = the deficiency of the lot average density, not to exceed 2.0%

Acceptance of all failing lots in the "Other" category will be made under the provisions of Article 105-3 of the Standard Specifications.

When the deficiency of the lot average density exceeds the minimum requirement, the Engineer will determine whether or not the mix is reasonably acceptable. If determined to be reasonably acceptable, the mix will be paid at an adjusted contract price in accordance with Article 105-3 of the Specifications. If it is determined not acceptable, the mix will be removed and replaced with mix meeting the requirements of these specifications. Any reduction in pay due to failing density will be in addition to any reduction in pay due to failing mix property test results on the same mix.

Perform the production and construction of all asphalt mixtures and pavements in accordance with these provisions. There will be no direct payment for work covered by this provision. Payment at the contract unit prices for the various asphalt items will be full compenstion for all work covered by this provision.

FIELD DENSITY ASSESSMENT PROGRAM

Mission

To evaluate the capabilities of the project personnel who are performing the Quality Control (QC) and/or Quality Assurance (QA) testing on FHWA funded projects by observation and comparative testing and sampling.

Scope

Evaluation and assessment shall be performed on QC and QA personnel on Design/Build projects and those QC and QA personnel utilizing the Nuclear Density Gauge on Asphalt bases and pavements. Evaluation and assessment shall also be performed on NCDOT and CEI personnel performing density testing of embankments, subgrades, and aggregate base courses.

Observation

The Independent Assurance Inspector (IAI) is to observe and evaluate the project personnel perform the testing/sampling procedure and the testing equipment. This includes QC and QA personnel on Design/Build projects and those QC and QA personnel utilizing the Nuclear Density Gauge on Asphalt bases and pavements, as well as NCDOT and CEI personnel performing conventional and nuclear density testing. All equipment utilized in testing must be in good working order and calibrated prior to the test. Any procedure that is performed improperly on the part of the project personnel shall be noted on a 901 form and brought to the attention of project personnel. The project personnel have the opportunity to review the appropriate testing/sampling manual and correct the procedural irregulaity. If the project personnel proceed without performing any corrective action, then the IAI shall contact the Technical Trainer who shall resolve the issue. Any procedural irregularity shall result in a poor rating being assessed against the project personnel. It is the intent of the Program to assess the technician who is routinely performing the density testing on any particular project. The IAI shall review project records to determine the technician, who routinely perform the tests, and arrange to perform the assessment.

IA Test/Sample

Once the IAI has observed the test/sampling procedure, they will perform a comparative test of take a comparative sample at a location near the test/sample site in accordance with the IA Manual.

If the results of the correlation rate fair or poor an investigation is required. If the investigation determines that a procedural irregularity on the part of the project personnel, then a poor rating shall be assessed against the project personnel.

Assessment Frequency

The IAI shall assess each technician performing field density testing every 2 months.

Resolution of Testing/Sampling Procedural Irregulations

If the irregularity can be resolved on site, the resolution shall be noted on the 901 form and a copy of the 901 delivered to the Soils Engineer.

If the irregularity cannot be resolved then a Technical Trainer shall investigate and resolve the issue. A copyy of the 901 is sent to the Soils Engineer. The Technical Trainer prepares a report, which is sent to the Soils Engineer and to the IA Supervisor.

Suspension of Certification

If project personnel have one or more procedural irregularity during a certification period their certification to perform density testing or materials sampling may be suspended.

Any falsification of testing or sampling information shall result in suspension of certification.

The project personnel may regain their certification by demonstrating to the Soils Engineer that they have the ability to perform the tests correctly. This shall be done by successfully taking the certification course offered by the Soils Engineer. However, if the certification was suspended due to falsification, or any other action that is deemed to be contrary to the proper spirit of this program, then the suspension shall be permanent.

Resolution of Testing/Sampling Disparities

Disparity is the difference between the results of the IA test/sample and the project results. If the disparity is outside the correlation limits an investigation is required. If the investigation shows that the disparity was a result of procedural irregularities then the policy governing procedural irregularities shall be followed. However, it is understood that, in some cases there is no clear apparent reason why a disparity occurred. Those cases shall not be considered as grounds for possible suspension of certification.

Training

The IAI do not train the project personnel, nor does the IAI have any role in the certification process. IAI's are to renew their certification in Conventional Density and ABC Sampling every year.

Confidence Limits Tables

ABC & Asphalt (Nuclear Density)				
Properties	Sign	Excellent Maximum Limit	Good Maximum Limit	Fair Maximum Limit
% Compaction	+/-	2.0	2.5	3.0

RECORD & REPORT FORMS

A typical set of forms utilized in Nuclear Testing is included in the following pages. The Contractor's QC forms with required supporting documents shall be retained by the Contractor for at least three (3) years after

completion of the forms. The Department's QA forms shall be stored indefinitely by the QA Labs unless permission is given otherwise.

CONTROL STRIP DENSITY

DATE [1]

Contract/Project No. [2] **County** [3] **Control Strip No.** [4]

From Sta. [5] **to Sta.** [6] **Lane** [7]

Layer [8] **Depth** [9] **Width** [10] **Route** [11] **Job Mix Formula** [12]

Gauge Serial No. [13] **Material** [14] **Crew No.** [15]

STANDARD COUNTS Density	ASPHALT CORE SAMPLES
[16] System 1	Core No. / Sta. / %Compaction
_____ System 2	_____ [18] _____ %
[17] Allowable Standard Count Range	_____ _____ _____ %
_____ +1.0% System 1 -1.0% [17]	_____ _____ _____ %
_____ +1.2% System 2 -1.2% _____	_____ _____ _____ %
	_____ _____ _____ %
	Avg. % Compaction _____% (A)

Test	Station	ASPHALT (Wet Density)
1	[19]	[20]
2		
3		
4		
5		
6		
7		
8		
9		
10		

AVG. (PCF) [21] **(B)**

ASPHALT TARGET DENSITY

Average of Control Strip (PCF) + Average of Cores (B+A) 100 = [22] **(C) Target Density (PCF)**

A = Core Sample Average B = Average PCF of Control Strip C = Correlated Target Density

cc: *Resident Engineer [White] *QA Copy Only
QA/QC Technician [Gold]
Soils Engineer [Pink]

Print Name Legibly w/ HiCAMS #: [23]

QA/QC TechnicianSignature: [24]

NOTE: By providing this data under my signature and/or HiCAMS certification number, I attest to the accuracy and validity of the data contained on this form and certify that no deliberate misrepresentation of test results, in any manner, has occurred.

12-02

INSTRUCTIONS FOR M&T 514 QA/QC

GENERAL NOTE: This form to be completed by both the QA and QC Nuclear Density Technicians when a control strip is tested to determine a correlated target density. (Refer to nuclear gauge operator's manual for control strip frequencies.) The Contractor's gauge operator will always correlate his/her gauge to the control strip core samples. The Department's gauge operator will correlate his/her gauge to the control strip samples at the same time as the Contractor's gauge operator, if possible. The Contractor must notify the Department's Roadway Technician far enough in advance of placing a control strip so the Department can provide a gauge operator at that time. Distribution of this form should be as follows: The QC Density Technician will maintain the gold copy. The QC Technician will provide the other two (2) copies to the Department's Roadway Technician at the end of each days operation when a control strip is placed. These will be attached to the daily roadway report (M&T 605) and forwarded to the Resident Engineer. The pink copy will be forwarded to the M&T Unit to the Soils Engineer. The white copy will remain on file at the Resident Engineer's office. When this form is completed by the Department's QA gauge operator, he/she will keep the gold copy. The QA Technician will give two (2) copies to the NCDOT Roadway Technician and distribution will be the same as above for the QC copies.

1. Date mix was placed, compacted and tested
2. Contract number or Project Number that mix is being placed on (Not individual work order numbers)
3. County in which Contract is located
4. Sequential control strip number for each type mix being placed (Refer to Nuclear Gauge Operators Manual for procedures for numbering control strips)
5. Beginning reference station number of the control strip
6. Ending reference station number of the control strip, not to exceed 300 L.F. from beginning of control strip
7. Lane on which control strip is placed (i.e. NBL - Lt. Ln., WBL - Rt. Ln.)
8. Layer of type mix being placed (i.e. B25.0C 1st layer, S9.5B 2nd layer, etc.)
9. Thickness of layer being placed (i.e. 1 ½ ", 1", 3 ½ ", etc.)
10. Width of layer being placed (i.e. 10', 12', 24', etc.)
11. Road number or Route number (i.e. US-1 North, SR-1559, I-40, etc.)
12. Job Mix Number of mix type being placed
13. Nuclear Gauge Serial Number (usually etched into handle of Nuclear Gauge)
14. Type Material being tested (See JMF i.e. B25.0C, S9.5B, etc.)
15. Crew number (once established remains the same for entire project)
16. Actual number from gauge when taking standard counts witnessed by the Department
17. Calculated Allowable Standard count range for subsequent days. This range is determined by adding ± 1% from the standard count.
18. QC or QA Core sample number, station number, and % compaction of core samples in the control strip. This information is transferred from the QC-5 form
19. Actual station number control strip core samples were placed
20. Nuclear gauge readings in pounds per cubic foot. Two (2) gauge readings must be taken on each core sample location in the control strip. Five (5) non-nuclear gauge readings must be taken on each core sample location in the control strip (only the average of the five readings will be recorded on the form for each core location).
21. Average pounds per cubic foot of the ten (10) nuclear gauge readings or 25 non-nuclear gauge readings at core sample locations
22. Correlated target density to be entered in gauge for determining density of a sections (Avg. PCF divided by core sample average x 100)
23. QA or QC Technician's printed name and HiCAMS nuclear gauge operators certification no., depending on who completes form
24. QA or QC Technician's signature certifing that data entered on this form is true and correct.

M&T 516QC
Rev. 12/02

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

DAILY NUCLEAR DENSITY TEST SECTIONS / SUMMARY

Date _____ **[1]** _____ **Control Strip Number** _____ **[2]** _____ **Crew No.** _____ **[2a]** _____

Project No. _____ **[3]** _____ **Job Mix Formula** _____ **[4]** _____

Map Number _____ **[5]** _____ **Type Material** _____ **[6]** _____

Contractor _____ **[7]** _____ **Layer** _____ **[8]** _____

Division _____ **[9]** _____ **Gauge Serial No.** _____ **[10]** _____

CORE SAMPLE AVG.: (A) _____ **[11]** _____ **AVG. PCF OF 10 READINGS: (B)** _____ **[12]** _____

DENSITY EQUIVALENT TO 100% COMPACTION: C = (B÷A)100 = _____ **[13]** _____ **PCF**

(B)Average of Control Strip (PCF) ÷ (A)Average of Cores =(C)=(B ÷ A x 100) = Correlated Target Density

Interim Density Checked With Calculated Target: 62.4 PCF x _____ **[14]** _____ **=** _____ **[15]** _____ **Calculated Target**
PCF G_{mm}

STANDARD COUNTS

_____
[16]
_____

TO BE COMPLETED BY QC NUCLEAR GAUGE OPERATOR											
Test Sect. No.	Beginning Station	End Station	LANE	INDIVIDUAL TEST RESULTS % COMPACTION (1)	(2)	(3)	(4)	(5)	Test Sect. Avg. % Comp.	PASS	FAIL
[17]	[18]	[19]	[20]	[21]	[21]	[21]	[21]	[21]	[22]	[23]	[24]
				LOT AVERAGE					[25]	[26]	[27]

cc: Resident Engineer [White]
QC Technician [Gold]
Soils Engineer [Pink]

***Print Name Legibly w/HiCAMsNo.** _____ **[28]** _____

***QC Technician Signature:** _____ **[29]** _____

**By providing this data under my signature and/or HiCAMS certification number, I attest to the accuracy and validity of the data contained on this form and certify that no deliberate misrepresentation of test*

INSTRUCTIONS FOR M&T 516 QC

NOTE: (1.) All failing lots must be documented by Resident Engineer on the QA-2B form. Contractor must be notified by letter of any pay adjustment or pavement removal.

GENERAL NOTE: This form to be completed daily by the Contractor's Density Control Technician when nuclear density control is being utilized to perform quality control testing of the compaction process. This form is to be distributed as follows: The gold copy is maintained by the QC Density Technician. Two (2) copies are given to the Department's Roadway Technician and attached to his/hers daily roadway report (M&T 605) and forwarded to the Resident Engineer. The Resident Engineer will then forward the pink copy to the M&T Unit's Soils Engineer and the white copy is kept by the Resident Engineer for the project files.

Actual Standard Count number from nuclear gauge (must be performed each day)

1. Date asphalt layer is actually placed, compacted and tested
2. Sequential number of the control strip per mix type

2a. Crew Number (once established remains the same for the entire project)

3. NCDOT Project Number (Always prime project no. if contract has more than 1 work order no.)
4. Job Mix Formula Number of HMA being tested
5. Actual work order map no. within a contract
6. Type of HMA being tested (i.e., S 12.5C, I 19.0B, etc.)
7. Name of Contractor placing and compacting asphalt mix
8. Layer of mix being placed (i.e.,1st layer S 9.5 B, 2nd layer S 9.5 B, etc.)
9. Division in which contract is located
10. Gauge serial number if applicable (usually etched into handle of a nuclear gauge)
11. Actual average percent compaction of control strip core samples from M&T 514 QA/QC
12. Average pounds per cubic foot of the ten (10) nuclear gauge readings or 25 non-nuclear gauge readings taken in the control strip
13. 100% equivalent target density determined after core sample results are known {(#12 ÷ #11) x 100}.
14. Gmm (rice specific gravity) determined at mix verification or Gmm moving average if mix has been previously produced or a 17 day lapse in in production of this mix has occurred
15. Calculated target density in pounds per cubic foot (62.4 pcf X #14)
16. Actual number from gauge when taking standard count. Must be within the acceptable standard count range from the control strip standard count. (Must be performed each day)
17. Consecutive number of test sections for each type mix per paving operation. (See Nuclear GaugeOperator's Manual for procedures for numbering test sections.)
18. Reference station number for beginning of each test section
19. Reference station number for ending of each test section
20. Lane being paved (i.e., Rt. NBL, Lt. EBL, etc.)
21. Individual gauge readings in percent compaction at 5 random locations throughout each test section. (Average of 5 non-nuclear gauge readings)
22. Average of the five (5) random percent compaction nuclear gauge readings or 25 non-nuclear gauge readings within each test section
23. Check if test section meets or exceeds minimum density requirement
24. Check if test section fails to meet minimum density requirement
25. Average percent compaction of each lot tested. (Only one lot per M&T 516QC -- See HMA/QMS Manual for lot determination).
26. Check if average of all test sections meets or exceeds minimum density requirements
27. Check if average of all test sections fails to meets minimum density requirements
28. QC Technicins printed name and HiCAMS certification number

29. Signature of QC Techician certifing data listed on this form is true and correct

M&T 515 QA
Rev.12/03

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
TEST SECTION DENSITY VERIFICATION

Date [1] **County** [2] **Gauge Serial No.** [3]

Project No. [4] **Map No.** [5] **Test Mode** [6]

Control Strip No. [7] **QC Test Section No.** [8] **From Sta.** [9] **to Sta.** [10]

Lane [11] **Layer** [12] **Material** [13] **Crew No.** [13 a]

STANDARD COUNTS
Density
[14]

Correlated Target Density [15] **PCF**

62.4 PCF x [16] / G_{mm} = [17] **Calculated Target PCF**

QA TESTS NO. [18]

Test [19]	Station	Asphalt Percent Compaction	Requirement Percent Compaction	Pass	Fail	QC Test Avg. %	Within Limits of Precision YES / NO	
1	[A]	[B]		[E]	[F]			
2								
3								
4								
5								
Average		[C]	[D]			[G]	[H]	[I]

Control Strip No. [7] **QC Test Section No.** [8] **From Sta.** [9] **to Sta.** [10]

Lane [11] **Layer** [12] **Material** [13] **Correlated Target Density** [15] **PCF**

QA TESTS NO. [18]

62.4 PCF x [16] / G_{mm} = [17] **Calculated Target PCF**

Test [19]	Station	Asphalt Percent Compaction	Requirement Percent Compaction	Pass	Fail	QC Test Avg. %	Within Limits of Precision YES / NO	
1	[A]	[B]		[E]	[F]			
2								
3								
4								
5								
Average		[C]	[D]			[G]	[H]	[I]

cc: Resident Engineer [White]
QA Technician [Gold]
Soils Engineer [Pink]

*** Print Name Legibly w/HiCAMS No.:** [20]

***QA Technician Signature:** [21]

***Note: By providing this data under my signature and/or HiCAMS certification number, I attest to the accuracy and validity of the data contained on this form and certify that no deliberate misrepresentation of test results, in any manner, has occurred.**

INSTRUCTIONS FOR FORM M & T 515QA

GENERAL NOTE: This form is to be completed by the Department's QA Nuclear Gauge Operator when performing retest and verification tests of a QC technician's test section. Only the density results of one mix type, one project number, and one control strip is to be used on this form. Distribution will be as follows: QA Technician will maintain the gold copy and furnish remaining two (2) copies to the NCDOT Roadway Technician to be attached to Form M & T 605 and forwarded to the Resident Engineer. Resident Engineers will forward the pink copy to the M & T Lab's Soils Engineer and the white copy will remain on file at the Resident Engineer's office.

1. Date quality assurance comparison test is performed
2. County in which the work is being done
3. Actual gauge number if applicable (usually the number etched into handle of gauge)
4. Prime project number for contract that mix is being placed
5. Specific work order map number, if applicable
6. Mode in which test will be performed. (always be backscatter mode for nuclear gauge)
7. Applicable control strip number from M & T Form 514 QA/QC
8. Actual QC test section number that is being tested
9. Beginning reference station number of test section being tested
10. Ending reference station number of test section being tested
11. Lane being paved (i.e. Rt. EBL, Lt. NBL)
12. Mix layer being tested (i.e. 1st layer S 9.5B, 2nd layer S 9.5B)
13. Mix type being tested (i.e. I 19.0B, S 9.5A, etc.)

13a. Crew number (once established remains the same for the entire project)

14. Actual standard count number from nuclear gauge. (Must be performed each day.)
15. Actual correlated target density entered into gauge from Form M & T 514 QA/QC
16. Gmm (rice specific gravity) determined at mix verification or Gmm moving average if mix has been previously produced or a 17 day lapse in production of this mix has occurred
17. Calculated target density in pounds per cubic foot (62.4 pcf X #14) entered into the gauge when checking interim density
18. This number will be the same base number as the QC test section number but will have a suffix of either "QA" for retest or "V" for verification tests. For example; if the Contractor's test section number is 24, a QA retest would be 24QA and/or a QA verification test would be 24V
19. Test section information:
    a. Station numbers of individual random gauge reading within a test section
    b. Actual percent compaction of individual random gauge readings within a test section
    c. Average percent compaction of the five random gauge readings
    d. Minimum density requirement for type mix being tested; i.e., 92%
    e. Check if individual readings and / or average meets or exceeds minimum density requirement.
    f. Check if individual readings and / or average fails to meet minimum density requirement
    g. Average percent compaction of QC test section being tested from Form M & T 516QC and from gauge printout
    h. Check if QA results are within +/- 2% of the QC test results
    i. Check if QA results are not within the +/- 2% of the QC test results
20. QA Technician’s printed name and gauge operators HiCAMS certification No
21. **QA Technician’s signature certifing that data entered on this form is true and correct**

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
NUCLEAR GAUGE RANDOM LOCATION WORKSHEET

M&T – 517QC/QA
Rev. 11/03

PROJECT: [1] CONTRACTOR: [2] DATE: [3]

MAP/RT. NO.: [4] TYPE MIX: [5] LANE: [6] JMF: [7] WIDTH: [8]

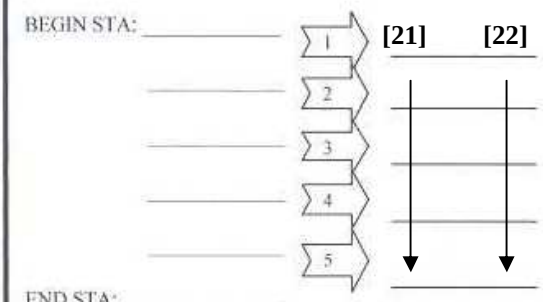
TEST SECTION: [9] BEGIN STATION: [10] END STATION: [11] LENGTH: [12]

TEST SECTION INCREMENTS [LENGTH/5]: [13] /5 = [14]

RANDOM #		TEST SECTION INCREMENTS		LENGTH/WIDTH x RANDOM #	
LENGTH A	WIDTH B	LENGTH C	WIDTH D	LENGTH A x C	WIDTH B x D
[15]	[16]	[17]	[18]	[19]	[20]

TEST SITE LOCATIONS

BEGIN STA: [21] [22]



END STA:

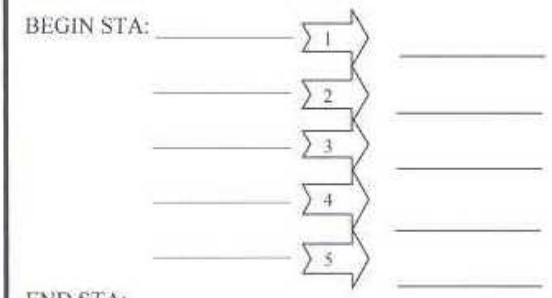
TEST SECTION: BEGIN STATION: END STATION: LENGTH:

TEST SECTION INCREMENTS [LENGTH/5]: /5 =

RANDOM #		TEST SECTION INCREMENTS		LENGTH/WIDTH x RANDOM #	
LENGTH A	WIDTH B	LENGTH C	WIDTH D	LENGTH A x C	WIDTH B x D

TEST SITE LOCATIONS

BEGIN STA:



END STA:

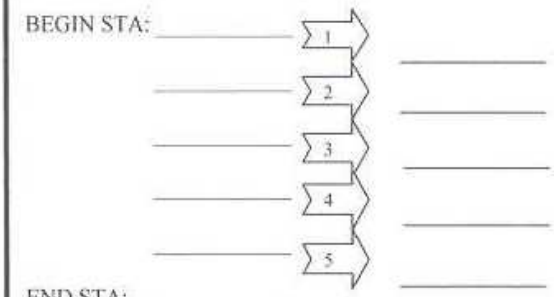
TEST SECTION: BEGIN STATION: END STATION: LENGTH:

TEST SECTION INCREMENTS [LENGTH/5]: /5 =

RANDOM #		TEST SECTION INCREMENTS		LENGTH/WIDTH x RANDOM #	
LENGTH A	WIDTH B	LENGTH C	WIDTH D	LENGTH A x C	WIDTH B x D

TEST SITE LOCATIONS

BEGIN STA:



END STA:

[23]
*PRINT CERTIFIED QMS TECHNICIAN NAME AND HICAMS #

[24]
*CERTIFIED QMS TECHNICIAN'S SIGNATURE

Provide this form at the request of a NCDOT and or QC representative. Maintain a copy of this form for 1 year after completion of project. QA maintain as outlined in Construction Manual.

*By providing this data under my signature and/or HiCAMS certification number, I attest to the accuracy and validity of the data contained on this form and certify that no deliberate misrepresentation of this data in any manner has occurred.

INSTRUCTIONS FOR M&T QA/QC

GENERAL NOTE: This form is to be completed daily by QA and /or QC Technicians when nuclear or non-nuclear density control is being performed on any NCDOT contract. There is no regular distribution of this form but the form shall be provided to any NCDOT or Contractor Technicians upon request. OC Technicians shall maintain this form for 1 year after the form has been completed and QA Technicians shall maintain this form as outlined in the current Construction Manual.

1. NCDOT contract number (always prime project number if contract has more than one work order number)
2. Name of Contractor placing and compacting the asphalt mix
3. Date asphalt layer is actually placed and compacted
4. Actual work order map number within a contract
5. Type of HMA being tested **(i.e. S-12.5 C, I-19.0 B etc.)**
6. Lane being tested **(i.e. NBL Rt., SBL Lt., etc)**
7. Appropriate Job Mix Formula Number of HMA being tested
8. Width of pavement layer being placed and compacted
9. Consecutive number of test sections for each mix type per paving operation. **(Refer to procedures for numbering test sections)**
10. Reference station number for beginning of each test section
11. Reference station number for ending of each test section
12. Actual length of test section being tested **(i.e. 2000', 1500')**
13. Actual test section length **(from #12)**
14. Actual increment length of each test site **(i.e. 400', 300')**
15. Actual random number from the random number tables used to determine random station number location
16. Actual random number from the random number tables used to determine random width location from a reference line
17. Actual increment length of each test site **(from #14)**
18. Width of pavement layer being placed and compacted **(from #8)**
19. Actual length to station number within each test site increment **{15 (A) x 17 (C)}**
20. Actual width from reference line to actual test site within each test site increment **{16 (B) x 18 (D)}**
21. Actual station number of each test site within each test section
22. Actual width from reference line to actual test site **(from #20)**
23. Printed name and HiCAMS certification number of certified technician
24. Signature of certified technician

RANDOM SAMPLING

In random sampling, a table of random numbers is used to locate test sites randomly to avoid biased testing. Once a number has been used it is marked through and not used again. For testing asphalt, a calculator that has a random number generator may not be utilized for generating random numbers. Random sampling is done in two dimensions by locating a station (length) and a pull distance from edge of base course (width). Refer to the following example. Use form M&T 517 QC/QA for determining random test sites

1. In the following example, the roadway is 12 feet wide; therefore, the test section is 2000 feet in length.

2. Divide the test section into five equal sections and record the beginning station of each section on scratch paper. Assume the test section begins at station 0+00 and ends at station 20+00.
   The data recorded on form M&T 517QC/QA as follows:
   2000 / 5 = 400 foot sections
   Beginning station - 0+00
   4+00
   8+00
   12+00
   16+00
   Ending station - 20+00

   NOTE: The greater than symbols will point to the randomly located test sites.

3. Determine the random sample multipliers by referring to the random sample number table. In the example shown below, refer to random sample number table. Looking at the first column of four digits, use the first two digits, which are 81. Place a decimal in front of these two digits (0.81). Go down the column and the next four multipliers are 0.41, 0.74, 0.91, and 0.16.

4. Multiply each random sample multiplier by the length of the five equal sections determined in #2 above. The increment length is 400 feet.

Test section increment:	400	400	400	400	400
Random number:	x 0.81	x 0.41	x 0.74	x 0.91	x 0.16
Distance:	324	164	296	364	64

5. Add the distance determined in #4 to the beginning stations of the sections determined in #2 to locate the stations where the readings will be taken.

Beginning station:	0+00	4+00	8+00	12+00	16+00
Distance:	3+24	1+64	2+96	3+64	0+64
Random test site:	3+24	5+64	10+96	15+64	16+64

6. Determine a second set of random sample multipliers to be used in determining the distance from the edge of the section where the tests are to located. Refer to the random sample numbers. Place a decimal in front of the second two digits in the first column and record these numbers on form M&T 517QC/QA. For this example the digits will be: 0.21, 0.85, 0.23, 0.53, and 0.17.

7. Multiply each random sample multiplier determined in #6 by the width of the section.

Width of section:	12	12	12	12	12
Random number:	x 0.21	x 0.85	x 0.23	x 0.53	x 0.17
Distance:	3	10	3	6	2

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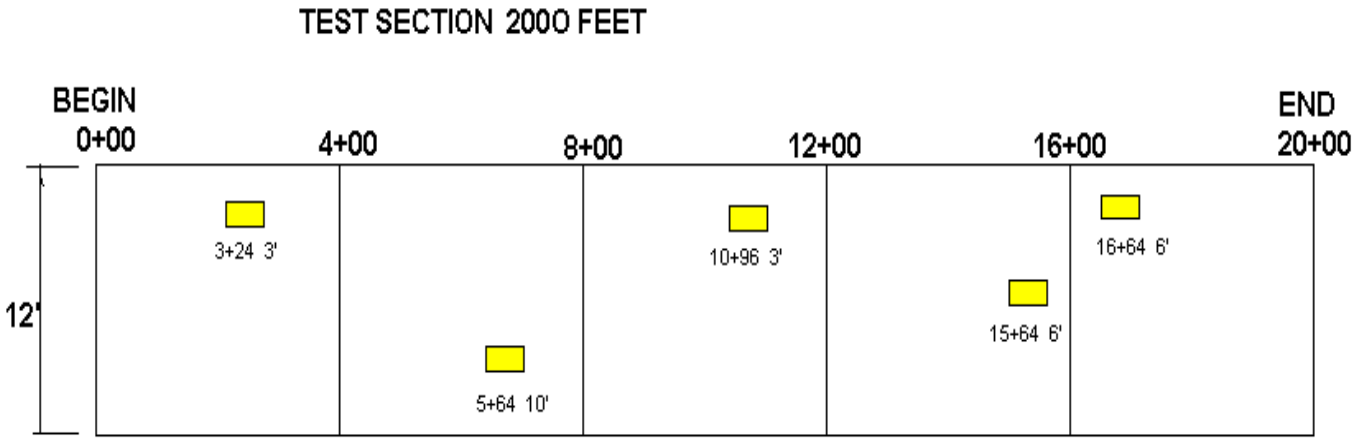
8. Refer to following page for M&T 517 QC/QA example.



TOP VIEW OF TEST SECTION

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
NUCLEAR GAUGE RANDOM LOCATION WORKSHEET

M&T – 517QC/QA
Rev. 11/03

PROJECT:____________ CONTRACTOR:____________ DATE:________

MAP/RT. NO.:________ TYPE MIX:______ LANE:_____ JMF:______ WIDTH:_____

TEST SECTION:______ BEGIN STATION:______ END STATION:______ LENGTH:______

TEST SECTION INCREMENTS [LENGTH/5]: ______ /5 = ______

RANDOM #		TEST SECTION INCREMENTS		LENGTH/WIDTH x RANDOM #	
LENGTH A	WIDTH B	LENGTH C	WIDTH D	LENGTH A x C	WIDTH B x D

TEST SITE LOCATIONS

BEGIN STA: ______ 1 ______
______ 2 ______
______ 3 ______
______ 4 ______
______ 5 ______
END STA: ______

TEST SECTION:______ BEGIN STATION:______ END STATION:______ LENGTH:______

TEST SECTION INCREMENTS [LENGTH/5]: ______ /5 = ______

RANDOM #		TEST SECTION INCREMENTS		LENGTH/WIDTH x RANDOM #	
LENGTH A	WIDTH B	LENGTH C	WIDTH D	LENGTH A x C	WIDTH B x D

TEST SITE LOCATIONS

BEGIN STA: ______ 1 ______
______ 2 ______
______ 3 ______
______ 4 ______
______ 5 ______
END STA: ______

TEST SECTION:______ BEGIN STATION:______ END STATION:______ LENGTH:______

TEST SECTION INCREMENTS [LENGTH/5]: ______ /5 = ______

RANDOM #		TEST SECTION INCREMENTS		LENGTH/WIDTH x RANDOM #	
LENGTH A	WIDTH B	LENGTH C	WIDTH D	LENGTH A x C	WIDTH B x D

TEST SITE LOCATIONS

BEGIN STA: ______ 1 ______
______ 2 ______
______ 3 ______
______ 4 ______
______ 5 ______
END STA: ______

____
*PRINT CERTIFIED QMS TECHNICIAN NAME AND HICAMS #

____
*CERTIFIED QMS TECHNICIAN'S SIGNATURE

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REFERENCES

1. "Manual of Operation and Instruction 4640-B Series Surface Moisture-Density gauge," Troxler Electronic Laboratories, Inc., Third edition, 1991.

2. "Manual of Operation and Instruction 3450 Roadreader Plus," Troxler Electronic Laboratories, Inc., Third edition, 1991.

3. “Pavement Quality Indicator Model 301 Operator’s Handbook,” TransTech Systems, Inc., 2002.

4. “Manual of Operation and Instruction Model 2701-B Pavetracker Plus,” Troxler Electronic Laboratories, Inc. 2004-2006.

NOTES